

FORTY-FIFTH ANNUAL REPORT

OF THE

Agricultural Experiment Station

OF THE

UNIVERSITY OF KENTUCKY

Lexington, Kentucky



PART II

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For the Year 1932



Part I.

Report of the Director
Meteorological Summaries

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LETTER OF TRANSMITTAL

To His Excellency, Hon. Ruby Laffoon, Governor of Kentucky.

Sir: In accordance with an act of Congress, approved March 2, 1887, entitled, "An Act to establish Agricultural Experiment Stations, in connection with the Agricultural Colleges established in the several states under the provisions of an act approved July 2, 1862, and under the acts supplementary thereto," and of the act of the Legislature of the State of Kentucky, approved February 20, 1888, entitled, "An Act to accept the provisions of an act passed by the Congress of the United States, approved March 2, 1887, for the establishment and maintenance of Agricultural Experiment Stations in connection with Agricultural Colleges established by the several states and territories under an act of Congress approved July 2, 1862," I herewith submit the Forty-Fifth Annual Report of the Kentucky Agricultural Experiment Station.

Very respectfully,

THOMAS P. COOPER, *Director.*

January 1, 1933.

ANNUAL REPORT
of the
Director of The Kentucky
Agricultural Experiment Station
For the Year 1932

The Kentucky Agricultural Experiment Station has passed thru a difficult year. Revenues from various sources declined, necessitating drastic economies, the suspension of employees and a curtailment of certain services. Despite decreased income, there was an increased demand upon the Experiment Station for assistance. Requests for information, personal conferences on individual farm problems, analyses, examinations and tests of seeds, commercial products and other materials were more numerous than in previous years. As the economic difficulties of the farmer became more severe, the demands for authoritative and full information multiplied.

The Experiment Station will fill an important place in the restoration and adjustment of agriculture. No other agency is equipped to give the type of information required or to conduct the researches which will so materially aid agricultural interests.

The results of investigations by the Experiment Station in the economic field have been used more widely than ever before. Facts and information bearing upon price, demand, consumption, the processes of distribution, farm organization and management, have been compiled sufficiently to be made of worth to agricultural extension agents and to farm groups. Such information and facts are the sound base upon which farmers may begin their readjustment program. Altho much

emphasis has been placed upon investigations in the field of agricultural economics, biological investigations, as they affect agriculture, have not been neglected. These researches have been energetically prosecuted.

Previous annual reports have pointed out the importance of the work of the Experiment Station in maintaining the economic welfare of agriculture. Annually, the results of present and past researches are converted into dollars and cents by the farmers who apply these findings to their farm practices. Comparatively inexpensive investigations often bring large and continuous returns to agriculture. To illustrate: An investigation of cheaper sources of materials for orchard sprays was undertaken. An oil spray was formulated which is now being used for dormant sprays. This spray is not only more effective but gives a longer period of control than the sprays formerly used. The annual saving in cost over that of formulas previously used varies from 50 to 80 percent, or from \$60 to \$400 each to growers in the important fruit sections. According to the statements of orchardists, the saving to the orchardists of the state from the use of this spray was approximately \$20,000 last year. Thus the annual saving from one piece of work represents two-fifths of the appropriation made by the state for the support of the Experiment Station. Similar or even more striking results might be cited from many other studies.

Commercial feed and fertilizer control, the public service laboratories, the creamery license section and seed laboratories, have performed a large amount of service during the year. Demands have increased to the extent that the present facilities of the staff and laboratories are overtaxed. These services are of direct aid and protection to the farmer, to many industries and to a very large group of citizens who are only indirectly interested in agriculture.

The varied activities of the Experiment Station for the year are presented briefly in this report. Results of work and detailed reports of research projects are issued from time to time in bulletins and circulars which are available upon request.

Farm Organization Studies. The studies in farm organization and management reveal that current prices for products sold by Kentucky farmers have been drastically reduced, whereas the cost of the items entering into production has increased. The result has been a marked reduction in farmers' net incomes. This is well illustrated by the figures for receipts and expenses of a typical group of farmers in central Kentucky, covering a period of 6 years and based on 162 records kept on farms in connection with a project in farm accounts.

RECEIPTS, EXPENSES AND NET INCOME OF A GROUP OF CENTRAL KENTUCKY FARMERS FOR THE 6 YEARS, 1926-1931.

(Based on 162 farm account records.)

	1926	1927	1928	1929	1930	1931
Total receipts	\$6190	\$6130	\$7640	\$6685	\$3818	\$3523
Total expenses	2831	3805	4216	4216	3911	2918
Farm income	\$3359	\$2325	\$3424	\$2469	—\$93	\$605
Interest on investment @ 5%	1700	1458	1589	1212	1746	1466
Labor income	\$1659	\$867	\$1835	\$1257	—\$1839	—\$861
Farm furnished products*	1155	831	804	634	684	566
Operator's earnings	\$2814	\$1698	\$2639	\$1891	—\$1155	—\$295

*Products for the family living.

The operators of these farms in 1931 had, on an average, total receipts of \$3,523, total expenses of \$2,918, leaving \$605 as payment for the operator's labor and management and for the use of a total investment of \$29,324. The poorer financial showing for 1930 was largely due to the low production occasioned by the unprecedented drouth of that season.

The problem of adjusting cost of production to a new price level is a difficult one. More than 700 farm business records obtained during the past year, which included all the important farming areas of the state, indicate that the average Kentucky farmer did not succeed in making this adjustment. However, the records show that in practically every area, some farmers succeeded in doing so. A comparison of the high-income farms with the farms of low income, based on an analysis of the busi-

ness of 40 Spencer County farmers for the year 1931, shows the total receipts of these farmers averaged \$1,763 and the total expenses, \$1,193, leaving \$570 as pay for the year's work of the operator and for the use of a capital investment of \$10,650. If 5 percent interest on the capital investment were subtracted from this figure, there would be left \$38 as the operator's labor income or his labor and management wage. In contrast with this figure, the labor income of the 10 farmers procuring the greatest income was \$546, while the 10 lowest farm incomes had a labor and management wage which averaged \$494.

The farms of high income excelled the low-income farms in labor accomplishment per man, in crop yields, in livestock production, in the number of cows, and the acreage of tobacco per 100 acres of land. These factors of superiority were principally responsible for the relatively high returns of the farms. These findings are typical of those furnished by the analyses of the businesses of more than 700 Kentucky farmers in 1931.

Farm Real Estate Taxation in Kentucky. The preliminary analysis of the data collected shows some significant trends in farm real estate taxes. Direct taxes on farm land in Kentucky rose from 15.8 cents per acre in 1913 to 41.8 cents in 1931. This was an increase of 26 cents per acre, of which higher school levies in 1931 accounted for 14.4 cents; greater county levies for 7 cents; increased special levies for 3.1 cents, and higher state levies for 1.5 cents. School taxes increased from 2.7 cents per acre in 1913 to 17.1 cents in 1931; county taxes from 6.2 to 13.2 cents; special taxes from .4 to 3.5 cents, and state taxes from 6.5 to 8 cents.

Considering the taxes paid per acre on farm land in 1913 as 100, the index of all farm taxes in Kentucky was 264.8 in 1931, having declined from 269.2 in 1930. Farm taxes in Kentucky were the highest in 1923 when the index stood at 276.7. In 1924, chiefly as a result of lowering the state tax rate on real estate from 40 to 30 cents per hundred, the index of farm taxes fell to 252.4. After 1924 the index rose to a new high of 271.1 in 1927 since which date, with the exception of one year, it has coursed downward.

The indexes of the several tax rates showed considerable variation among themselves. For instance, the index of state taxes stood at 122.7 in 1931, having reached a high of 169.5 in 1923. The index of county taxes, on the other hand, was 212.4 in 1931 after touching a high of 222.1 in 1926. Again, the index of school taxes reached a high of 655 in 1928 and had declined to 641.9 in 1931. Finally, the index of special levies varied markedly from year to year, reaching 945.1 in 1923 and falling to 618.9 in 1924, for example, touching a high of 950.5 in 1930, and standing at 897.4 in 1931.

The index of all farm taxes showed marked variations by crop reporting districts. The increase was greatest in Districts Two (Grant and Oldham Counties) and Six (Pike County) and least in Districts Five (Shelby, Fayette, Bourbon, Lincoln, Nelson and Woodford Counties) and Nine (Laurel County). In Districts Two and Six, farm taxes increased 221.2 and 191.7 percent, respectively, from 1913 to 1931, and only 131.8 and 133.2 percent, respectively, in Districts Five and Nine. Variation was least in the index of state taxes and greatest in school taxes. For instance, school taxes increased 823.5 percent from 1913 to 1931 in District Two (Grant and Oldham Counties) and only 434.1 percent in District Nine (Laurel County).

Analysis of the general situation in somewhat greater detail discloses that the trend in farm taxation during the past ten years has varied in different parts of Kentucky. For instance, from 1922 to 1931 the index of all farm taxes rose in five crop-reporting districts and declined in four. Declines in the index of state taxes on farm land were universal over this period for all crop-reporting districts, while the converse was true of school taxes. The index of county taxes, on the other hand, declined in four, and rose in five crop-reporting districts.

In conclusion, it may be stated that the index of farm taxes in Kentucky, while lower than in many states, is higher than in many others, and is essentially the same as that for the entire United States. In other words, Kentucky occupies an intermediate position among the several states in the matter of relative change in farm taxes from 1913 to 1931.

Economic and Social Studies in Submarginal Agricultural Areas. These studies, which have been under way in Eastern Kentucky during the past three years, were continued in 1932. Analysis of income records of families living on farms in Knott and Bell Counties added to the previous evidence, from this large section of Kentucky, of maladjustment in the use of land, due to steepness of slope, erosion and other physical handicaps to agriculture which unfit a great part of the land for agricultural use. Over a considerable portion of the area studied, the pressure of population has led to attempts to utilize, for the production of crops, land that is wholly unsuited to that purpose. The result has been to place many families on a bare subsistence.

Income data for the 25 farms shown in the table were obtained in the spring of 1932. Part-time or full-time work in the mines near the area has heretofore been a major source of income to many men living on these mountain farms. During the past year, operations have been discontinued in a considerable number of mines. Those which have not closed operated on an average of about 6 or 7 days a month. One of the immediate results was the drastic reduction or the total discontinuance of the income which farmers or their sons have been receiving for day work in the mines. It will be noted that for the 25 farmers in the 1931 tabulation, the income from "other sources" (largely work in the mines) was \$149, as compared with \$411 two years before. The reduction of income from this source has brought many farm families to a bare subsistence level and a good many have been the recipients of help from the Red Cross. Some of the miners have returned to abandoned shacks as tenants or squatters, with no money, livestock or equipment. A good many mine workers have returned to farms owned by relatives. Often, such men have built small box houses out of rough lumber, with their own labor and with a small expenditure of cash. The clearing of ground was considerably increased in 1932 to provide for the increased number of persons to be fed and to furnish occupation to the increased number of farm laborers. About 40 percent of the

farmers have engaged in new clearing, the area of clearing ranging in most cases between one and two acres. The low state of mine operations has almost cut off the buying power of those living in the mining camps; consequently the market for vegetables, fruits, eggs, poultry, milk, butter and other produce in the territory around the mines has largely ceased. This is reflected in the figures of incomes of the 25 farms.

INCOME OF 25 KNOTT COUNTY FARMERS IN 1931 COMPARED WITH
INCOME OF THE SAME FARMERS AND OF 228 OTHER
FARMERS IN 1929.

Items	Average 228 Farms 1929	Average 25 Farms 1929	Average 25 Farms 1931
Total investment	\$2812	\$1885	\$1899
Total receipts:	506	644	299
Crops	99	156	61
Livestock, net increase	66	67	52
Other sources (work off farm, gas leases, etc.)	333	411	149
Increase in feed and supplies	8	10	37
Total expenses:	215	183	190
Current	129	113	72
Unpaid family labor	71	56	101
Livestock net decrease			
Depreciation	15	14	17
Decrease in feed and supplies			
Farm income	291	461	109
Value of living furnished by the farm	481	530	309

These studies indicate that farm operators, whose acreages in crops include a large proportion of steep and heavily eroded land, would do better by spending all or a major part of their time in other employment, utilizing the farm principally as a residence and garden. Adequate income is dependent upon a good-sized acreage of suitable cropping land and the use of relatively intensive enterprises.

Improvement in conditions would result if cultivation of much of the land would be discontinued and the use of the land shifted to pasturage and to the growing of trees. The consolidation of many of the poorly utilized and managed tracts into large forest tracts under private or public ownership is needed.

Enlargement of forests into good-sized tracts would make possible the more adequate protection against fires, the application of greater skill in the care of the growing trees, and the more economical harvesting of the timber.

An effort should be considered to devise plans whereby farmers on submarginal farms might have an opportunity to shift to better farming lands. Such a shift would be greatly to their advantage and at the same time would tend to stop the denudation of large areas of hillside lands and would start such lands on the way toward the production of timber. Such a shift would reduce the difficulties and expense of maintaining social institutions and improvements and community services, such as schools, roads, churches, hospitals, and medical service, and would improve distinctly the chances of these farmers for obtaining such services as telephones, electrical current and the like.

Community and Neighborhood Groupings in Knott County.

The groupings studied in this mountain county have been brought together in a manuscript which includes the following set of six maps for the county: 1. Churches, showing location of buildings and areas of membership; 2. schools, showing buildings and school districts; 3. trade areas; 4. postoffices and mail routes; 5. lodges, agricultural extension groups and voting precincts; 6. school and church areas in 1860. Communities in this county were found to have changed remarkably during the past two decades. The extension of railroad lines to points on the borders of the county has resulted in new trade areas. Following this economic change, larger school areas and new lodge areas have been created. The neighborhood boundaries were determined almost entirely by the topography and have changed very little since the days of early settlement, except that the neighborhoods decreased in area and became more numerous as the density of population increased. The study reveals some conflicts in the adjustment to the new larger community groupings and supplies a basis for more rational choices in future development of community organizations in this and similar counties of the State.

Agricultural Credit and Finance in Kentucky. The study of the use of credit in 1929 by 406 large owner-operators of farms is of particular value, since the larger and wealthier farmers are most able to control their credit uses and practices in accord with their own best interests, once the assembled body of farm credit information is adequate to indicate fundamental truths and underlying interests. The general usefulness of the study has been greatly increased during the past year thru the inclusion of data obtained in the 1930 Census. One-third of this large group of farmers, located as they were in four separate and representative agricultural sections of the State, did not use credit of any kind in 1929. These farmers maintained cash reserves adequate to obviate the need of borrowing. The net worth of these farmers was 85.4 percent, or conversely, their combined indebtedness amounted to only 14.6 percent. The county range in net worth was from 71.6 percent in Christian to 91.7 and 92.6 percent, respectively, in Bourbon and Knott Counties.

A brief resume of other interesting facts disclosed by this study and not mentioned in past reports follows: (a) Farming occupies an intermediate position among the various industries, in its use of credit. (b) Farmers tend to make mortgage loans during periods of rising prices. (c) Local banks are commonly used by Kentucky farmers for the bulk of their production credit. (d) Farmer loans at local banks are greatest from September thru November, and during these months banks commonly have to borrow in order to accommodate their farmer borrowers. (e) Agriculture was apparently more commercialized on the mortgaged farms within the group studied. (f) Farmers obtain large volumes of credit annually from automobile dealers, the amount in three counties, in 1929, having been \$248,000. Also more than one half of the cars sold by dealers that year to farmers were second-hand. (g) Merchant credit was decidedly less important to these farmers than five years earlier. The volume of farmer accounts with merchants, as with bank loans, is greatest from September thru December. That farmers, like other consuming classes, are beginning to

trade extensively at cash stores is indicated by figures obtained in all counties, and particularly in Bourbon County, where 20 percent of the total farmer trade was with cash stores.

Factors Affecting Prices of Selected Agricultural Products. Research on this study has been directed toward prices of tobacco. A comparison has been made between preliminary crop estimates issued prior to the marketing season in previous years and the final estimates revised on the basis of actual marketings. It was found that in the last seven years, preliminary estimates of white burley tobacco have varied between the extremes of 12.2 percent too low and 12.6 percent too high, with an average error of 7.9 percent. Almost as satisfactory estimates were found to have been made for dark fire-cured tobacco, but estimates for the less important dark air-cured types showed greater discrepancies.

Market shifts in Kentucky tobacco production have been taking place. In 1922, white burley tobacco made up 50 percent of the state's total production, but in 1931, 68 percent of Kentucky's tobacco was white burley. The dark fire-cured types decreased in relative importance from 26 to 20 percent during the same period and the dark air-cured types decreased from 24 to 12 percent of the state's total.

Shifts in the location of production of the individual types also have been taking place. In 1922, for example, Kentucky produced 81 percent of all white burley tobacco; in 1931, only 73 percent was grown in this state. During this period, Tennessee production increased in relative importance from 6 to 14 percent. Production in Virginia also increased in importance. The relative importance of Tennessee in the production of eastern dark-fired tobacco also has been increasing. In 1922, the distribution of production was Kentucky 53 percent, Tennessee 47 percent, but in 1931, it had shifted to Kentucky 40 percent, Tennessee 60 percent. Production of the Paducah type, however, has been shifting toward Kentucky. In 1922, this state produced 78 percent of that type and in 1930 about 87 percent. Production data for areas within the state are not

available, but it is hoped that some information on shifts in production within the borders of the state may be worked out.

For the past three years, stocks of tobacco in the hands of dealers and manufacturers have been reported quarterly by groups of grades. A study of the percentage distribution of stocks in the different groups indicates a surprising uniformity from year to year and thruout the season. Some shifts are indicated, however. In burley, for example, the groups which are composed mostly of smoking tobaccos made up 50 percent of storage holdings in October, 1930, while the same groups made up only 43 percent of the holdings on October 1, 1932. These groups are not subdivided, so as to give information as to the average quality of stocks on hand. In Green River and Henderson stemming tobacco, the group classed as "Nondescript" increased from .03 to .52 of one percent in October, 1931 to 2.76 and 2.48 percent respectively, in October, 1932, thus reflecting the accumulation of lower grades from the 1931 crop.

In the dark-fired types 22 and 23, the proportion of stocks made up of heavy leaf has declined, while the thin leaf and lug groups have increased proportionately. In October, 1929, 75 percent of stocks of eastern dark-fired tobacco was made up of heavy leaf, but in October, 1932, only 64 percent was in this group. During the same period, the proportion made up of thin leaf remained about constant, while that of lugs increased from 11 to 24 percent. Similar and even more marked changes took place in stocks of western dark-fired tobacco. Such changes may be due to differences in the crops produced from year to year or to shifts in exports or domestic use. So far as the causes can be determined, they may be interpreted differently in tobacco outlook work.

While the different types of tobacco probably are quite distinct in their uses, yet some competition between types undoubtedly exists. A comparison of the prices paid for flue-cured and for white burley tobacco, for example, shows quite similar movements between the two types. When the price of flue-cured tobacco has moved up or down from one year to the next, the price of burley has made a similar movement 15 times out of

22. Most of the seven times when the prices moved in opposite directions can be explained by fundamental differences in supply and demand conditions. A similar comparison between the prices of Virginia dark-fired tobacco and the Kentucky, Tennessee dark-fired tobacco shows quite a close relationship between the prices of these types, altho not so close as that between burley and flue-cured.

Cost and Profit Margins in Livestock Production. In connection with the study of farm organization, detailed enterprise records were kept on livestock. These records included 28 herds of dairy cattle, 53 herds of beef cattle, 84 flocks of sheep and 44 droves of hogs.

The analysis of the sheep enterprise records showed a wide range from farm to farm in costs, gross returns and net returns. The 10 lowest-profit flocks gave a net income averaging only 5 cents a head, as a return for pasture and management, against \$3.63 a head for the 10 highest-profit flocks. In contrast with the low-profit flock group, the high-profit flock group (1) had more 2 to 4-year old ewes; (2) turned rams with ewes earlier; (3) had fewer death losses in the breeding flock; (4) sustained a smaller depreciation charge on flock; (5) lost fewer lambs; (6) raised a larger number of lambs per ewe; (7) made more economical use of feed; (8) produced heavier lambs; (9) sold more lambs in top and choice grades; (10) marketed lambs earlier; (11) received a higher price per pound for lambs. One-half the cost of maintaining sheep was for feed. Pasture made up three-fourths of the cost of feed. Depreciation on the flock constituted about one-third of the total cost of producing lambs and wool.

In the studies of the cost of producing milk and butterfat, the farms producing fluid milk were in Jefferson, Shelby and Bourbon counties. The group of farms selling butterfat were in Marion and Carroll counties. All farms studied had membership in Dairy Herd Improvement Associations. Each member kept farm accounts, supplemented with a labor record on the milking herd and complete production and feed records.

The amount of milk necessary to pay the cost of feed, labor, equipment, interest, depreciation, etc., depends both upon the cost of keeping a cow and the price received for the product. Using the average cost of keeping these cows and the average credits allowed for appreciation and manure, the amount of milk and butterfat necessary to pay costs at various prices is shown in the following table:

AMOUNT OF MILK AND BUTTERFAT PER COW NECESSARY TO
PAY THE COST

	With 1931 Costs	With Dec., 1932 Costs
When milk sells for:	Milk, lbs.	Milk, lbs.
\$1.00 per 100 lbs. _____	11266	7974
1.20 per 100 lbs. _____	9388	6645
1.40 per 100 lbs. _____	8047	5696
1.60 per 100 lbs. _____	7041	4984
1.80 per 100 lbs. _____	6259	4430
2.00 per 100 lbs. _____	5633	3987
2.20 per 100 lbs. _____	5120	3625
When butterfat sells for:	Butterfat, lbs.	Butterfat, lbs.
\$0.10 per lb. _____	688	439
.15 per lb. _____	458	293
.20 per lb. _____	344	219
.25 per lb. _____	275	176
.30 per lb. _____	229	146
.35 per lb. _____	196	125

In addition to the credits for appreciation and manure, a credit of 25 cents was allowed for each hundred pounds of skimmilk.

Economics of Hog Production in Kentucky. The hog enterprise on Kentucky farms accounted for 12 percent of the gross income of farmers in 1930, and for 23 percent of the gross income from livestock and livestock products. Hog production can be classed as a major farm enterprise in only a few counties of the state. Since 1900, hog production has become centralized in three small areas, (1) Henderson and Union counties, (2) Carlisle, Hickman and Fulton, (3) Warren, Simpson, Barren, Monroe and Cumberland, and a larger area consisting of most of the Bluegrass region. It is only in the first three areas, however, that hogs are produced on a commercial scale which approaches the level of production in the Corn Belt states.

Hog production in Kentucky is concentrated in the areas of heavy corn production. An exception is the Bluegrass area where hogs show considerably more concentration than does the production of corn and where the hog enterprise takes the form of production of feeder pigs. Corn-hog ratios have been computed for various parts of the state. The average corn-hog ratio for the 5-year period, 1926-1930, differed considerably in different sections. It was highest in the extreme western part of the state, where corn and hogs are produced in largest amounts, and lowest in the eastern or mountain section. The Bluegrass area and the South Central part of the state follow the other two, being about equi-distant between them. Even the highest corn-hog ratio, or that of the Evansville district is, on the average, more than a point below the average of the United States, as published by the United States Department of Agriculture. The mountain area is below the United States average by about three points.

Time of marketing is a factor that may affect profits in the hog enterprise. In an analysis of the seasonal movement of hogs to market in Central Kentucky, it was found that during the years 1929, 1930 and 1931, a rather large proportion of the slaughter hogs were sent to market during the month when the receipts at the terminal markets were low and prices were relatively high. When the receipts were divided into two classes—slaughter hogs and feeder hogs—it was found that the receipts of slaughter hogs were greatest in May and June, with a minor peak in October. From a study of these data, it can be concluded that hog producers in this area keep the bulk of the spring pig crop on the farm for use as meat, while the fall pig crop is either sold as feeders in the fall or finished out for the spring market and sold during the time when the usual spring rise in price occurs. With the abundant pasture that is available in this section of the country during the fall, fall pigs can be produced very cheaply and, on those farms which produce sufficient corn to finish them to slaughter weight, the cost of production is relatively low. This method enables producers,

particularly of the central portion of the state, to show a profit on the hog enterprise.

An analysis of the sale of 347,347 hogs sold during the years 1929, 1930 and 1931 at the leading auction markets in Central Kentucky was made. Hogs were classified according to weight and price. The price received increased with each weight increase up to 200 pounds after which prices declined with each weight increase. The hogs in the highest weight group sold for a lower average price than any of the other groups. The spread between the prices of the various weight groups was comparatively narrow and remained relatively constant with the exception of the one group weighing below 100 pounds. The price of this group reflecting fluctuations in the demand for feeder pigs showed considerable variation from the other groups both seasonally and from year to year. With the small price differential between various grades, the availability and price of feeds and the market price for hogs of various weights determine to a large extent at what weight hogs should be sold.

Fattening Hogs. A feeding test with hogs was conducted to determine the efficiency and economy of feeding middlings in the form of a thin slop or dry in a self-feeder. Ten shoters, lot 1, averaging 149 pounds at the beginning of the test, were fed shelled corn and a protein supplement consisting of 2 parts tankage and 1 part cottonseed meal in a self-feeder. This lot was fed middlings in the form of slop, limiting the middlings to about the amount consumed by lot 2. Water was supplied in a trough nearby. The shoters in this lot consumed 319 pounds corn, 64 pounds middlings and 52 pounds protein supplement, or a total of 435 pounds of feed per 100 pounds gain. The hogs gained at the rate of 1.76 pounds per head, daily, at a cost of \$3.94* per 100 pounds. Lot 2, ten shoters averaging 150 pounds at the beginning of the test, was fed corn and a protein supplement in the same manner as lot 1. but the middlings were supplied dry in a self-feeder. Water was in a nearby trough. The hogs in this lot consumed 333 pounds corn, 62 pounds middlings

*Based on following prices of feeds: Corn, 46c bu.; middlings, \$17.80 a ton; tankage, \$30 a ton; cottonseed meal, \$25 a ton.

and 46 pounds protein supplement, or a total of 441 pounds of feed per 100 pounds gain. The gain was at the rate of 1.74 pounds per head daily at a cost of \$3.95* per 100 pounds. The results show a little advantage in feeding the middlings in the form of slop, but not enough to pay for the labor involved.

Salmonella Aertrycke Infection of Foals. An outbreak of infectious colitis in suckling foals was found to be due to *S. aertrycke*. All the animals affected were on the same farm. In a group of twenty-eight foals, sixteen became ill and eight died. *S. aertrycke* was isolated from six foals which were presented for post-mortem examination. It was also isolated from blood culture, before death, in cases that proved fatal and from the feces of two foals that recovered. None of the older animals on the farm were affected. An autogenous bacterin prepared from the organism was apparently very effective in controlling the disease. Three foals became ill the day following the first administration of the bacterin. These three foals died. No further cases occurred.

So far as is known, *S. aertrycke* infection of foals has never before been reported in this country. The disease was characterized by high temperature, diarrhea and colitis. On post-mortem examination, almost complete destruction of the intestinal mucosa was observed. Occasionally ulcers were found in the stomach or intestines. The microorganism was found constantly in the intestinal mucosa. In addition it was sometimes present in one or more of the internal organs. Three of the six cases were septicemic; in two, the liver was the only internal organ yielding the bacterium on culture. In one case, *S. aertrycke* was found in the stomach and intestines only.

Differentiation of Streptococci. The work which has been done on this group of microorganisms represents the first instance in which *Streptococcus epidemicus*, the cause of septic sore throat in the human, has been definitely differentiated from certain closely related strains of streptococci of animal origin. Both are found in the udder of cattle and, therefore, differentia-

*Based on following prices of feeds: Corn, 46c bu.; middlings, \$17.80 a ton; tankage, \$30 a ton; cottonseed meal, \$25 a ton.

tion is important in outbreaks of infectious mastitis of cattle and of septic sore throat in the human.

Studies of the streptococci isolated from genital diseases and prenatal infections of the horse, infectious rhinitis of foals, influenza, pneumonia and wound infections of adult horses showed that these organisms possessed the characters generally attributed to streptococci of human origin. They produced a low acidity in glucose broth, failed to hydrolyze sodium hippurate and were actively hemolytic in fluid mediums. The same type of streptococcus has also been found in cows, hogs, chickens, rabbits, guinea pigs and foxes. There has been a general lack of recognition of the fact that streptococci possessing these biochemical properties were present in the lower animals. One hundred and sixty-five strains from animal, and one hundred and fifteen cultures from human, sources have been compared. All the human cultures fermented trehalose, but did not produce acid from sorbitol. Ninety-six percent of the animal strains fermented sorbitol, but did not attack trehalose. The remaining animal cultures acted upon these two substances as did the human strains. Under appropriate conditions, the small group of animal cultures which possessed the fermentative characteristics of human streptococci were all able to reduce methylene blue, while only four percent of the human strains reduced the dye under the same conditions. By the use of the methods mentioned, it is now possible to distinguish streptococci of human and animal origin with a high degree of accuracy. Less than five percent of the strains studied have not been differentiated.

The large group of sorbitol-fermenting streptococci of animal origin all produced capsules and grew in large, spreading colonies on blood-ascitic-fluid agar, thus possessing all the cultural and biochemical characteristics generally attributed to *Str. epidemicus*. Sixty-five stock cultures labelled *Str. epidemicus* were obtained from six laboratories working on this species. Two distinct types were present in this group. One type was identical with the sorbitol fermenting streptococci of animal origin, the other resembled the human strains. From

one laboratory sixteen cultures were received, all of which resembled the animal type. Twelve of these had been isolated from cows, the remainder were said to have been isolated from humans. Duplicates of three of the four strains said to be of human origin were obtained from the laboratory originally distributing them. The duplicates were of the human type. A second laboratory furnished twelve cultures, two of which resembled the animal type. Duplicates of these two cultures were obtained from the laboratory in which they were isolated. The duplicates were again found to belong to the human type.

From the results obtained to date, it is obvious that two types of streptococci are being classified as *Str. epidemicus*. One type is of animal origin, the other type of human origin. It was demonstrated that stock cultures in some laboratories have been mislabelled or admixture of types has occurred. Sorbitol-fermenting streptococci of animal origin are probably not the cause of septic sore throat in the human, and this type occurs rarely, if at all, in human disease. Certain cultures have been studied which were isolated from the udders of cows responsible for epidemics. Their cultures were of the human type, demonstrating that under certain conditions animals may become carriers of human streptococci.

The Prevention of Breeding-Diseases in Horses. Since the spring of 1929, observations have been made and records kept of a group of brood mares and their foals which were maintained and handled with the purpose of preventing breeding diseases. The group varied in number from 14 to 20 mares. When first observed, there were 14 mares; six in foal and eight barren. Of the eight barren mares six were badly diseased. From the beginning the policy has been not to breed any mare known to have an infection of the reproductive organs. This applied to barren mares and to those that had foaled recently. During four foaling seasons, forty foals have been dropped all of which were normal and healthy at birth. Two foals died as sucklings; one aged 70 days, from atrophy of the liver, cause unknown; the other, aged 90 days, from injury. One maiden mare, first pregnancy, aborted; cause streptococci infection. The number

of services per pregnancy, including all mares bred, has never exceeded two during any one breeding season. Breeding hygiene, as a fundamental principle and in detail of execution, has been carried out and the results demonstrate the effectiveness of the policy.

Together with the breeding hygiene program a parasite prevention program was adopted. The acreage available for paddocks and pastures was not sufficient to permit the adoption of a pasture rotation scheme. The practice followed has been special care of pastures and systematic treatment of animals. The paddocks and pastures have been limed, chain harrowed, mowed several times during the summer, raked and the grass and weeds hauled off. No stable manure was spread on the fields and for the past two years droppings in the field have been removed once each week. All brood mares have been treated for parasites at least twice in the fall of each year. The foals were treated regularly every sixty days from the time they were four months old until they were put in training as yearlings. All new stock and horses in training returned to the farm were treated for intestinal parasites before being turned on pasture.

Clinical evidence of parasitisms among the horses on the farm are altogether absent. No cases of colic have occurred since the treatment and the preventive measures were begun. The only digestive disturbances have been a few mild cases of indigestion due to constipation. All colts raised are retained by the owner for racing. The trainer reports that the horses from this farm have as a group been unusually free from sicknesses and ailments to which the average group of horses in training are subject.

The Eradication of Bang Abortion Disease. In 1923, a dairy herd of 41 cows was tested by the agglutination test for Bang abortion infection (*Brucella abortus*): Twenty-nine of the cows were negative, 11 positive and one suspicious to the test. Previously, this herd had suffered severely from an outbreak of abortion, altho for two years there had been considerable improvement. When the result of the test was known, the re-

actors were immediately removed, and only animals negative to the agglutination test were retained. During the past three and a half years, the whole herd has been tested five times. The first test was made in June, 1929; forty-one animals, 29 negative, 11 positive and 1 suspicious. Second test; November, 1929; 31 animals, all negative. Third test, February, 1930, thirty animals, all negative. Fourth test, March, 1931, forty-four animals, all negative. Fifth test, December, 1932, thirty-eight animals, all negative. During this time, 7 cows in milk and 11 heifers have been purchased, all of which were negative to the test. Twenty cows have been sold, the majority because of low production. All were non-reactors, regular breeders and normal in every way.

Breeding troubles, such as sterility, delayed conception and retained afterbirths, are practically unknown in this herd. There have been a few cases of mastitis due to injury, but no cases of udder trouble of bacterial origin. It is an exception to encounter a herd having over 25 percent reactors on the initial test and no reactors on any subsequent retests over a period of three and a half years. The good results obtained in this herd are attributed mainly to two factors; first, immediate removal or strict isolation of all reactors and effective sanitation; second, infection in the herd was temporarily more or less dormant following an acute virulent outbreak. Experience with Bang's disease leads to the conclusion that efforts to control, prevent and eradicate the infection should be a primary and fundamental part of all dairy herd management programs. The initiation of a program leading to final eradication and the establishment of a Bang's disease-free herd is to be recommended regardless of the condition of the herd. However, it is just as important and often less expensive to test the herd even though there is no visible evidence of the disease than to wait until the disease breaks out in an acute form.

Results of tests for Bang's disease show that out of 15,173 samples of blood tested by the agglutination method, 85.1 percent were negative; 12.7 percent positive and 2.2 percent suspicious. This includes both initial and re-tests. Of 997 cows

tested for the first time, 72.8 percent were negative, 24.2 percent positive and 3 percent suspicious. On retest of the 2,485 cows which were negative and suspicious on first test, 90.5 percent were negative, 7.6 percent positive and 1.9 percent suspicious. In the retest group a few animals that were positive on first test are included, which tends to raise the percent of reactors found on retest. For Kentucky, the average reactors in herds tested for the first time is approximately 25 percent. The average of reactors on retest of animals negative and suspicious on first test, is approximately 6 percent.

Infectious Abortion. A differentiation has been completed of 51 strains of *Brucella abortus* (Bang), *Br. abortus suis* and *Br. melitensis*, by the agglutinin-absorption method as compared with the dye plate method. Of the 39 strains of bovine origin, 37 were classified as *Br. abortus* (Bang) by both tests and 2 were classified as *Br. abortus suis* by both tests. One human strain was classified as *Br. abortus* (Bang) by both tests. Of the five strains from swine, 3 were classified as *Br. abortus suis* by both tests and 2 as *Br. abortus* (Bang) by the agglutinin-absorption test and as *Br. abortus suis* by the dye plate method. Of the six melitensis strains, one was classified as *Br. abortus* (Bang) by both tests, 4 were classified as *Br. abortus* (Bang) by the agglutinin-absorption test and as *Br. melitensis* by the dye plate method.

Bacteriological examinations were made from milk from each of the four quarters of two cows, No. 57 and No. 27, that reacted positively to the agglutination test for infectious abortion. The samples of milk were collected in sterile flasks after the first milk had been discarded, and about 10 cc of each was centrifuged. Cultures were made on liver agar from the sediment and from the cream. At the same time guinea pigs were inoculated intra-abdominally with 5 cc of whole milk from each quarter. A period of 54 days was allowed to elapse before making an autopsy. The spleen, liver, kidney and heart were then examined culturally for the presence of *Br. abortus* (Bang).

The bacteriological examinations of the milk and cream were all negative. The guinea pig inoculations were all negative ex-

cept that from the pig injected with the milk from the left hind quarter of cow No. 57. This guinea pig aborted two fetuses 52 days after receiving the injection. The spleen of this pig was greatly enlarged and the liver had many small, white spots on its surface. *Br. abortus* (Bang) was isolated from the spleen and liver. The fetuses were cultured, with negative results. The internal organs of the other guinea pigs were normal.

Vaccine was prepared from *B. abortivo-equinus* and administered to 1874 mares on 52 farms. Forty-nine samples of equine blood were tested for abortion. Thirty fetuses were cultured and a streptococcus was isolated from five of them; twenty-three were negative and *B. abortivo-equinus* was isolated from the other two. The mares that aborted the fetuses positive to *B. abortivo-equinus* were from a herd which had never been vaccinated for this disease. There were seventeen mares in foal, two produced live foals and the other fifteen aborted. Only two of the fetuses from this herd were submitted for laboratory examination.

Acidosis of Pregnant Ewes. The work during the year with the experimental flock and with the field cases confirms the statement made last year that acidosis of pregnant ewes is a nutritional disorder and that the history, clinical symptoms, urinalysis and the Ca/P ratio of the blood are necessary in making a diagnosis. It further appears that a dys-function of endocrine glands accompanies the disease.

In connection with the investigation of acidosis of pregnant ewes, 2131 chemical determinations of the blood and urine of 22 heifers were made. Nine of these heifers were from two weeks to three and a half months old. They were fed milk, grain and hay. Three of them received mangels in addition, and three others received a mineral mixture. It is interesting that with the very young heifers the addition of mangels or the addition of a mineral mixture to their feed did not show results in their weight, condition, growth or blood analysis, yet did show a decided difference in their urinalysis. Those heifers not receiving mangels or mineral mixture showed a constant albuminuria indicating a distinct metabolic disturbance. This

conclusion agrees with those of other investigators who, on adding a mineral mixture to the feed of dairy cattle, obtained no results in weight, condition, growth or milk production. They did not, however, analyze the urine.

Animal Parasites. Post-mortem examinations of domestic animals during the year revealed that a large percent were heavily infested with internal parasites. Either directly or indirectly, the parasites were responsible for sickness and death. Among the parasites found were several encountered for the first time in this state, namely: *Pentastomum taenioides* from dogs, commonly spoken of as the "tongue worm"; *Echinococcus granulosus* from the liver of pigs; and *Bunostomum trigonocephalum* (sheep hookworm) from the intestines of sheep. While the hookworm of sheep is a comparatively rare parasite, yet it is most serious. In one flock, the sheep were found heavily infested and losses were high.

Coccidiosis. This disease is apparently becoming increasingly prevalent in the state. Coccidia have been identified in seven different species of animals, namely; cattle, sheep, swine, chickens, dogs, turkeys and quail. The quail were raised in captivity. A number of cases of coccidiosis in cattle have been diagnosed. In one large herd, 40 animals were sick with intestinal coccidiosis. The mortality in bovine coccidiosis is usually not high, but the disease is of serious economic importance.

Development of the Turkey Embryo. Embryonic growth was measured by wet weight, dry weight and ash content, from the fifth to the twenty-sixth day of incubation. The calcium and phosphorus content of the 13- to 26-day (inclusive) old embryos was also determined. The study shows that there are three distinct phases or cycles of embryo growth with definite periods of retardation between the ninth and tenth, and also between the nineteenth and twentieth days. The results suggest that the calcium content of the embryo may be used as a measure of growth if the yolk material drawn into the body cavity is removed before analyses are made.

The Iron and Copper Content of Egg Yolk. Egg yolk has been found by some investigators to be effective in hemoglobin regeneration in anemia. It has generally been assumed that this is so because of its iron content. As copper, too, is important for the formation of blood, it is of interest to know both the iron and copper content of the egg yolk and whether under different conditions of production the amounts vary.

Accordingly, eggs were collected from six different pens and the egg yolks analyzed for copper and iron. The pens were paired. The ration for one pen of each pair included two percent cod liver oil. The hens of the first pair were confined with exposure to sunshine only thru ordinary window glass. The hens of the second pair were confined, but exposed to direct sunshine on a wire-screened sun porch. The hens of the third pair were allowed open bluegrass range.

The percentage iron content of the egg yolk was increased slightly, but definitely by cod liver oil. The effect of sunshine and of bluegrass was not shown so clearly, but the iron content showed a tendency to increase in the eggs produced in the pens where the hens were on bluegrass range and exposed to sunshine. The effect of cod liver oil was less pronounced when given to hens that were exposed to sunshine, and still less when both sunshine and bluegrass were available in addition to the cod liver oil.

All three factors had a marked effect on the copper content of the egg yolk. The egg yolks of hens in each of the three pens which were given cod liver oil showed an increase in copper content. Sunshine resulted in an increase in copper content as also did sunshine plus bluegrass. A steady rise was noted in the copper content of the egg yolk from the hens in pen 1, which were kept in confinement, without sunshine, cod liver oil and bluegrass, to that of the hens in pen 6, which had sunshine, cod liver oil and bluegrass. The percentage value of pen 6 was 2.5 times that in pen 1, while that of pen 5, in which the hens had sunshine and bluegrass but no cod liver oil, was only 1.7 times that of pen 1. The effect of cod liver oil alone is shown by the

fact that pen 2 had 1.4 times as high a percentage of copper as pen 1.

The deduction may be made, therefore, that eggs produced by hens allowed open bluegrass range and in addition given 2 percent cod liver oil have possibly a higher value for hemoglobin regeneration than eggs not so produced.

Vitamin D Supplements for Laying Hens. Interesting and valuable results have been obtained from the three years' work in testing the value of cod liver oil when added to the ration of laying hens, (1) confined to laying house (2) allowed access to direct sunshine on a wire-screened porch and (3) allowed bluegrass range. In each instance, there was a decided increase in egg production as a result of the addition of bluegrass range, direct sunshine or cod liver oil, singly or in any combination. The addition of cod liver oil did not result in any increase in the egg production of pullets on bluegrass range except during one of three winters, namely, the coldest winter with the least sunshine. Cod liver oil did not increase egg weight and had little effect on the average weight of chicks. It was found that under Kentucky conditions, bluegrass range and sunshine provide ample supplements to a balanced ration to insure high hatchability, without the use of cod liver oil. Cod liver oil did improve the hatchability of eggs from pullets that were confined and from those that received direct sunlight on a screened porch but had no range.

Confinement vs. Colony Brooding. Three groups of White Leghorn chicks were fed the same ration and raised under the following brooding conditions: (1) colony brooded with access to bluegrass range and direct sunlight (2) battery brooded to 6 weeks, transferred to colony brooder, and (3) battery brooded to 24 weeks. Pullets raised under the first two conditions greatly exceeded in production those that were raised to laying age in the battery brooder, altho the fertility and hatchability of the eggs was the same for the three groups.

The fertilizing capacity of cockerels raised in battery brooders was quite low as compared with cockerels raised under the

other two conditions. This was due partly to the enlarged combs of the cockerels raised in confinement which impeded successful mating and also to the smaller number of spermatozoa in the semen.

The removal of the combs from four-weeks-old White Leghorn cockerels caused the development of larger wattles and testes when the cockerels were raised in battery brooders. This increase in size of wattles was not caused by fatty infiltration but was probably a response for the need of additional surface area for the absorption of the radiant energy of the sun. The removal of the pullets' combs at four weeks had no apparent effect on ovarian development up to 14 weeks of age.

The production, mortality and condition of the birds raised under the conditions set forth indicate that it is not practical nor economical to raise in battery brooders under confinement either laying pullets or breeding stock.

Selective Flock Breeding. The sixth year of this breeding project was completed for both Barred Plymouth Rocks and White Leghorns and the results bear out the conclusions set forth in previous reports. The average winter and yearly egg production for both breeds for the first five years was given in the 44th annual report. This year there was a drop from 73 to 56 eggs for the winter, and from 187 to 151 for the year from the 1930-31 records with Barred Plymouth Rocks, thus indicating that the practical limits had been reached. The White Leghorn pullets laid 60 eggs as against 65 the previous winter and 189 as against 185 for the previous year. During the past five years, the flock averages have been 181, 182, 183, 185 and 189 eggs respectively, indicating very slow progress after the initial increase of from 153 the first year to 181 eggs the second year. The culling and selection of untrapnested females failed to raise the production of the offspring up to 200 eggs even tho pedigree cockerels out of hens from 240 to 260 eggs were used each year.

Effects of Outcrossing on Egg Production. The plan of work was described in the 43d annual report and the results

brought up to date in the 44th annual report. During the year, the F/3 pullets, which were 7/8 Kentucky blood and only 1/8 outcross blood, completed their year of lay. A careful study of the data accumulated since 1929 indicates that outcrossing usually results in improvement in rate of maturity, winter and yearly egg production, hatchability and egg weight. That outcrossing frequently brings about improvement along these lines is probably because the particular males introduced into the flock contain the factors (genes) which bring about the improvement. Mere outcrossing has no merit unless the males introduced are from strains bred for production qualities. It is interesting to note that of the two original outcross cockerels of the same strain (Beall) one was decidedly superior to the other, whereas if outcrossing in itself had caused the improvement, both males should have done equally well.

Method of Feeding Grain to Laying Pullets. The first year's conclusions, which were reported in the 44th annual report, were verified by this year's results with 75 Barred Plymouth Rock and 50 Rhode Island Red pullets per pen. During the winter of 1931-32 the litter-fed Barred Plymouth Rock pullets averaged 71 eggs and the hopper-fed pen 72 eggs per bird. The yearly production was 181 and 169 eggs, respectively. Both pens of Rhode Island Red pullets averaged 61 eggs each for the four winter months, while for the year the litter-fed pen laid 162 eggs and the hopper-fed pen 165 eggs. The total feed consumption was slightly greater in the hopper-fed pens, but since these pens consumed a much larger proportion of grain to dry mash than the litter-fed pens, the total feed cost was no greater. The Leghorns as reported in 1930-31, on the average, consumed 5 pounds of feed for each dozen eggs produced, irrespective of the method of feeding the grain. The litter-fed Barred Plymouth Rocks consumed 5.4 pounds, and the hopper-fed pen 5.9 pounds for each dozen eggs laid. From the comparative results with the three breeds when giving consideration to egg production, sanitation, mortality, labor and hatching of the eggs, it was concluded that the hopper-feeding of grain is pre-

ferable for layers and breeders to the commonly practiced method of scattering grain in the litter.

Composition of Forest Leaves. Sixty-three samples of leaves, collected in 1931 from 21 of the more important species of forest trees growing in the vicinity of the Experiment Station, were analyzed for moisture, ash, silicon, copper, iron, manganese, zinc, calcium, magnesium, phosphorus, potassium, sodium, sulfur, nitrogen, fat and crude fiber. The data were tabulated and the results discussed in a paper which was published in the Botanical Gazette. The results of the analyses indicate that different species of trees show wide differences in the amounts of mineral nutrients removed from the soil. Two of the species, sweet gum and black oak, contained nearly twice as much manganese as iron, which is a very unusual relationship in comparison with the other species of leaves dealt with in this investigation.

Boron Studies. Experiments carried on in the latter part of 1931 showed that boron apparently performs a very necessary function in the growth of lettuce. Further investigations show that the effect of boron deficiency in lettuce is very similar to, if not identical with, the disease formerly known as "tip burn." The addition of minute quantities of boron to cultures after the development of the disease, caused the resumption of normal growth. Three different varieties of lettuce were used and all were affected in a similar manner when boron was withheld from the cultures.

Further progress in boron studies has resulted in the devising of a new spectroscopic method of the determination of boron in plant material, animal tissues, natural waters, rocks and soils.

Nutrients Necessary to Impart Vitamin Potency to Yeast. The yeast plant is a very desirable species for experimental investigations concerning the mineral and organic nutrients necessary for the production of vitamin potency. Yeast cells produced from a pure synthetic culture in 1931 failed to produce so satisfactory a growth in rats as an equal amount of brewers'

yeast, when fed as supplements to a synthetic diet. This experiment showed that the yeast cells produced under controlled conditions with regard to the mineral and organic nutrients did not possess vitamin potency comparable with that of a commercial sample of brewers' yeast. This observation led to a number of experiments, the purpose of which was to ascertain what mineral nutrients and their most favorable concentration, and what forms of nitrogen compounds, produce the most favorable growth of yeast cells. The results of these experiments show that inorganic forms of nitrogen, such as ammonium sulfate, ammonium phosphate and ammonium tartrate are as suitable for the growth of yeast as organic nitrogen compounds, including the amino-acids, glycine, tryptophan, tyrosine, lysine, leucine, histidine, creatine, nucleic acid, cystine and asparagin. The conclusion was reached that no particular nitrogen compound as the source of nitrogen is the principal cause of the high vitamin potency of brewers' yeast. A large number of experiments have been carried out to test the effect on the growth of yeast of the addition of different concentrations, singly and in combination, of barium, strontium, arsenic, fluorine, selenium, bromine, iodine, uranium, rubidium, cesium and lithium. The best growth of yeast cells resulted from certain concentrations of compounds of boron, bromine, iodine, rubidium, cesium, lithium and uranium. Having ascertained the optimum conditions for the growth of yeast cells, it is now proposed to grow them in sufficient quantity for a detailed chemical analysis to ascertain in what quantities the various mineral nutrients have been assimilated by the yeast cells and if the yeast cells possess a normal vitamin potency when fed to rats.

Iodine Researches. A study was undertaken to determine the iodine content of the principal soil areas of Kentucky and of the food crops produced on these areas. In the absence of sufficient data, Kentucky has been classed as an iodine-deficient state. Approximately 1,000 analytical determinations were made of the iodine content of soil samples from the six principal geological areas in Kentucky. The results show that some soil areas are relatively high in iodine while a few are low in this

clement. However, the general average of approximately 500 samples of soil analyzed to date from the six principal geological areas show that Kentucky soils, with few exceptions, are adequately supplied with iodine.

About 60 samples of limestone have been analyzed for iodine. The maximum result was 7,500 parts of iodine per billion, which is about ten times more iodine than was found in some depleted soils. It is evident, therefore, that limestone deposits may be of value as a source of iodine in depleted soils. Iodine has been determined in about ten samples of marl and the average for this number of samples is approximately 800 parts per billion. Apparently marls do not contain as much iodine as some limestones.

During the early autumn of this year, a sample of fresh whole milk was obtained from cows that were being grazed on a good bluegrass pasture and receiving no other feed. The sample contained 30 parts of iodine per billion.

During the spring and fall months, analysis was made once a month of samples of milk taken from three cows, one of which received no iodine except that contained in normal feed, whereas the other two were given potassium iodide in their rations. The milk of the cow that did not receive iodine except normally, contained approximately 50 parts per billion, while the milk from the cows that had iodine added in their feed contained as much as 400 parts per billion. It is possible, therefore, to greatly enrich the iodine content of milk by feeding an iodine compound such as potassium iodide. Further experiments are contemplated in this connection to ascertain if iodized milk is more potent than normal milk having a comparatively low but normal iodine content.

Samples of colostrum were procured in glass containers from three cows in the Experiment Station dairy herd, within twelve hours of parturition. The samples contained 492, 426 and 276 parts of iodine per billion, respectively. At the first feeding following parturition a mineral mixture containing potassium iodide was added to a balanced grain mixture of corn, wheat bran and cottonseed meal. Each pound of grain

fed contained .009 gram of potassium iodide. Samples of milk from the same cows were taken on the fourth day following parturition and were found to contain 400, 330 and 198 parts of iodine per billion, respectively. Sixty days later, the milk from the same cows analyzed 187, 175 and 282 parts of iodine per billion, in the same order. At this point, the mineral mixture containing the potassium iodide was removed from the ration of the first two cows and the result during a five months period, was a gradual and continued decline in the iodine content of the milk to 60 and 72 parts per billion, respectively. The third cow was continued on the mineral mixture containing the potassium iodide and five months later her milk was found to contain 260 parts of iodine per billion.

Score of Butter from Cream Graded According to the 4-Day Plan. Records were obtained for 1932 from a commercial dairy plant on churnings made from cream graded according to the 4-day grading plan, from cream delivered without consideration as to time, and from mixtures of cream representing both methods of delivery. The butter resulting from each churning was scored. A study of butter from 144 churnings made during June, July and August, together with the percent of 4-day or "premium" cream in each churning, reveals a relationship between the amount of 4-day cream in the churning and the score of the resulting butter. There appears to be a progressive increase in the average score of the butter as the percent of butterfat from 4-day cream in the churning increases. The largest difference between the average scores of any two groups is that between the butter made entirely from 4-day cream and that made from cream containing from 81 to 99 percent of 4-day cream. The difference amounted to one full point in favor of butter made from 4-day cream. The next largest difference was between the butter containing no 4-day cream and that containing 20 percent of 4-day cream. The difference in score between these groups is .48 of one percent. The average scores of the churnings containing 100 percent of 4-day cream showed far more improvement over the average score of the groups containing 81 to 99 percent of 4-day cream than the

latter showed over the groups containing 1 to 20 percent of 4-day cream. This indicates that in the manufacture of butter a small amount of cream over four days old may offset the advantage gained by using a large amount of cream less than four days old.

Nitrogen Fixation in the Soil. Small plots, laid out on the Experiment Station farm at Lexington in September, 1923, were treated as follows to determine the rate of fixation of atmosphere nitrogen: (1) Kept free of vegetation by scraping with a hoe; (2) seeded to bluegrass, volunteer grass allowed to grow, but kept free of legumes; (3) seeded to bluegrass and white clover. Much sweet clover was present in 1925. In other years, the vegetation was mainly bluegrass and white clover. There are duplicate plots for each treatment. Until the end of 1928, vegetation was removed occasionally from the plots with treatments 2 and 3. Since then it has been clipped frequently and allowed to lie. The plots were sampled for nitrogen determinations in the fall of 1923 and at about the same time in 1924 and 1931. The effects of the treatments on nitrogen content of the soil, averaging the analyses of the 1923 and 1924 samples and of the duplicate plots, and expressing on the acre basis, are shown in the following table.

Treatment	Lbs. nitrogen in 0-6" soil depth (assumed 2,000,000 lbs. dry soil)			Lbs. nitrogen in 6-18" soil depth (assumed 4,000,000 lbs. dry soil)			Loss (—) or Gain (+) 0-18" Soil Depth
	Average 1923, 1924	1931	Loss (—) or Gain (+)	Average 1923, 1924	1931	Loss (—) or Gain (+)	
1. Bare	2346	2486	—360	3740	3572	—168	—528
2. Grass	2795	2682	—113	3474	3648	+174	+61
3. Grass & Legumes	2977	3149	+172	3850	4082	+232	+404

Effect of Various Rotations and Farm Manure Treatments on Soil Supply of Nitrogen. Plots in the crop rotations and farm manure experiments on the Station farm at Lexington, were sampled for nitrogen determinations shortly after they were begun in 1921, and again in 1930. In one experiment, a comparison is made of rotations of corn, wheat and red clover, orchard grass or soybeans, depending on the rotation. Each of the last three is handled as a hay crop (except as noted in the summary) No commercial fertilizer, farm manure, cornstalk or wheat straw residues have been applied to the plots. The loss (—) or gain (+) in soil nitrogen, in pounds per acre to a depth of 18 inches (6,000,000 lbs. assumed dry soil weight), during the nine-year period between sampling for the various rotations is as follows:

Rotation with:

1. Red clover (average duplicate plots)	+527
2. Orchard grass	—10
3. Soybeans planted in rows and cultivated (average two plots: on one the soybeans follow wheat; on the other, corn)	—94
4. Soybeans drilled solid (threshed and straw returned after 1927)	+200

In another experiment corn is grown continuously (with rye cover crop). Different amounts of farm manure are applied on different plots in alternate years. In a third experiment, farm manure is applied in different amounts and at different times in a three-year rotation of corn, wheat and clover. No commercial fertilizer, cornstalk or wheat-straw residues have been added to the plots in either of these experiments. The loss (—) or gain (+) in soil nitrogen, in pounds per acre to a depth of eighteen inches (6,000,000 lbs. assumed dry soil weight) during the nine-year period between sampling, is as follows:

Continuous corn:

No manure (average 3 plots)	—228
10 tons manure per acre	—112
15 tons manure per acre	+76

Three-year rotation:

No manure (average 6 plots)	+93
4 tons manure per acre for corn (average 2 plots, one treated with manure before and the other after plowing)	+239
10 tons manure per acre for corn (average 2 plots as above)	+393

These results should be considered in relation to the degree of accuracy possible in total soil nitrogen determinations. The crop yields in these experiments are reported in Kentucky Experiment Station Bulletin No. 331.

Soil Nitrate-Nitrogen Level and Growth of White Burley Tobacco. Tobacco was grown (1931) in small plots on the Experiment Station farm at Lexington, with optimum mineral nutrient supply but with different amounts of nitrate maintained in different plots, ranging up to 100 pounds of nitrate-nitrogen per acre. Determinations of nitrate were made from time to time during the growing season. Sodium nitrate was applied as necessary to maintain desired nitrate levels. Straw was added to one plot after plowing and disked in, to maintain a low nitrate level. Quality was best on the straw plot where determinations showed no nitrate in the soil, except early in the season. It decreased with increased amount of nitrate. The increase in yield from the nitrogen additions, however, just about made up in total crop value for the decrease in quality, not considering the cost of the fertilizer application.

Tobacco Mosaic. For the seventh consecutive year, tobacco mosaic was practically controlled at setting time on the Experiment Station farm. There was .07 percent mosaic in 65,300 plants three weeks after setting. The only precautions taken were to have the plant beds weeded by a man who did not use tobacco and require the men to wash their hands before pulling the plants, and if using tobacco, to substitute a manufactured plug for the usual barn-cured tobacco. At the time the counts were made, the only other virus present was ringspot in .07 percent of plants. At topping time, in one field of 10,700 plants, there was .54 percent mosaic and in another field, of 9,454 plants,

there was 4.75 percent. The latter field had been in tobacco the previous year, when there was 2.7 percent mosaic at cutting time. The difference in the two fields suggests carry-over of mosaic in the soil of the latter.

Soil carry-over of mosaic was studied in a field in which tobacco had been grown each year for about 20 years. When all the plants, about 900, on one-half of the field were inoculated with mosaic in the fall of 1930 and the stalks from these plants cut up and returned the following spring, plants set in the infested half developed 9.3 percent mosaic and in the uninfested half 3.4 percent. In the fall of 1931, half of the plants on the infested side were inoculated with yellow tobacco mosaic and the others with green, and all mosaic plants were removed from the other side of the field. The stalks of both yellow and green mosaic plants were cut up and returned to the infested half of the field in 1932 before setting. By topping time, plants in the uninfested side developed 1.8 percent mosaic and on the infested side 16 percent. Both yellow and green mosaic appeared on the infested side, but yellow mosaic was found on no other part of the Station farm, indicating that both it and green mosaic had originated either from overwintering roots or from stalks added to the soil. Green mosaic was about five times as abundant as yellow mosaic. Greenhouse tobacco plants rubbed with mud from the infested half of the field and then set in a flat of infested soil, developed both green and yellow mosaic in the late winter and spring of 1932, proving the overwintering of both mosaics either in soil or decaying plant parts.

In attempting to determine the methods by which mosaic enters the plants from the soil, it was found that rubbing the roots with a mosaic decoction, or dipping the cut ends of the roots into it, resulted in infection. When the roots were rubbed with the fingers on which fresh mosaic juice had been dried about 15 seconds, infection did not occur. When tobacco leaves were rubbed gently with the fingers on which fresh mosaic juice of yellow mosaic had not yet dried, local infections were 5.8 times as numerous as when the material was allowed to dry on the fingers for about 15 seconds. When the roots of Turkish tobacco

plants which had been growing in tumblers were removed and rubbed either with green or yellow mosaic decoction, infection occurred, the incubation period being from 17 to 40 days. The greenhouse results suggest that infection from soil in the field occurs through broken roots at setting time and not subsequently, the long incubation period explaining the lateness of appearance of the disease.

In the study of mosaic burn, a leaf-spotting which is frequently severe on mosaic plants, it was found that White Burley plants inoculated while still growing rapidly were more susceptible to burn than plants inoculated when leaf growth was nearly completed. Burning usually occurred in leaves which were only partly grown when infection took place and not in leaves which had acquired nearly their full size. Burning appeared to be more severe on leaves exposed to the direct rays of the sun during the middle of the day.

To determine the extent to which mosaic might be spread during the worming process, the hands were rubbed with a mosaic leaf until wet and then allowed to dry. Each leaf of 306 plants of burley was handled with the flat of the hand, care being taken to bruise as little as possible. Fourteen percent of the plants became infected. When the hands were kept wet, simulating worming in damp weather, 35.5 percent of the plants became infected. It is evident that during the worming operation, mosaic will spread if the hands are contaminated, indicating the desirability of poisoning worms, instead of worming by hand, if mosaic is present in a field. Seven hundred White Burley tobacco plants, topped after topping mosaic plants, developed 16 percent mosaic.

Black Root-Resistant Strains of Tobacco. No. 5 White Burley, developed thru hybridization, was tested this year by 1,600 farmers in all parts of the White Burley section of Kentucky. As indicated by reports from these trials, the outstanding features of this variety are (1) vigor of growth in the plant bed, being earlier by a week or more in many beds; (2) rapidity of growth following transplanting—in many instances much less

re-setting was necessary than with the common variety; (3) uniformity of type and growth, thus simplifying the operations of topping and stripping; (4) earliness of maturity in one fourth of the fields, No. 5 was topped an average of 10 days earlier than the common variety; (6) high quality; (7) a much higher degree of resistance to black root-rot than the resistant selections previously introduced.

In connection with the breeding of black root-rot resistant varieties of burley tobacco, a study was begun of the relative resistance of White Burley varieties and strains to *Fusarium* wilt. The commonly grown varieties of White Burley appear to be very susceptible to the disease, but there is enough difference in resistance of the hybrid strains to indicate that resistant varieties may be produced. Turkish tobacco has proved highly resistant but not entirely immune from infection.

Angular Leaf-Spot of Tobacco. This disease appeared suddenly in plant beds of white burley tobacco over an extensive area in the Central Bluegrass region. Double treatment of seed with silver nitrate and the usually recommended sanitary precautions failed to give control of the disease. Complete control was obtained in 1300 square feet of bed to which one or two applications of Bordeaux mixture were applied, the first when the plants were just developing the first true leaves, and the second two weeks later. Altho at the time of the second application of Bordeaux mixture to the treated portion of the bed, no signs of the disease were evident in the remainder of the bed of about equal area, yet four days later the untreated portion was severely affected by the disease.

An outbreak of leaf-spot of black tobacco following topping occurred in several areas in western Kentucky. The angular leaf-spot organism was isolated and typical angular leaf-spot reproduced in the greenhouse, but the presence of the organism on the well-developed leaves was considered incidental. Numerous attempts to duplicate the large concentric type of spot which developed in Western Kentucky failed when black tobacco plants on the Experiment Station farm and in the

greenhouse at Lexington were inoculated at different stages of growth with the angular leaf-spot organism.

The thermal death point of *Bacterium angulatum* has been found to be 10 minutes at 52° C, suggesting that the seed treatment of 20 minutes at 52° C may be effective in destroying the organism on or in tobacco seeds. This treatment does not injure tobacco seed, as demonstrated by several years' plant-bed tests.

In a study of relative susceptibility of tobacco leaves inoculated on upper and lower surfaces, it has been found that infection with angular leaf-spot rarely occurs thru the upper surfaces if the leaves have attained nearly their maximum size at the time of inoculation, whereas leaves in the growing point are equally infected thru the upper and lower surfaces. Susceptibility of tobacco leaves to angular leaf-spot infection seems to increase from the lower leaves upward, as indicated by the size of the spots which develop, the largest and most characteristic spots being developed on the smallest and tenderest leaves. On older leaves, heavy infection with an atomizer resulted in large, faintly chlorotic, non-necrotic areas made up of numerous infections.

Method for Calcium Determination in Plant Extracts. An indirect method for determining calcium in plant extracts has been developed. A known amount of phosphoric acid is added to the acid plant extract and the solution is made strongly alkaline with sodium hydroxide, and filtered. Phosphate is determined colorimetrically in the filtrate. The calcium is precipitated as tricalcium phosphate, thus diminishing the quantity of phosphate in solution proportionally to the amount of calcium present. The difference between the original phosphate and the phosphate after precipitation gives the amount of calcium present. Magnesium and iron do not interfere, since they form insoluble hydroxides and do not reduce the phosphate concentration. The method was found to be even more accurate and much more rapid than the oxalate method for small amounts of calcium in plant extracts.

Effect of Soil Moisture on Tomatoes. Tests were made in quadruplicate to determine the effect of 10, 20 and 40 percent

moisture in the soil, on the growth of tomato plants and on nitrate, phosphate and potassium content of the plants. Ten percent moisture resulted in hard, stunted, dark green plants with small fruits. Twenty percent resulted in vigorous plants of medium vegetative growth and a good set of fruit. Forty percent resulted in large, succulent plants with a poor set of fruit. The dry soil caused the plants to accumulate large amounts of nitrate nitrogen and potassium in the tissues (green weight basis). In all cases a reduction of moisture in the soil reduced the phosphate phosphorus present in the plant.

Rotation Experiments with Tobacco. The most interesting development in the rotation experiments in recent years is the marked superiority of the tobacco and plots treated with manure. This is true both where the manure is used directly on tobacco and where it is applied to a preceding crop. In the earlier years of the experiment nitrogenous fertilizer gave as good results as manure. Now even heavy applications of complete fertilizer are not giving quite as good results as manure. In this experiment the tobacco on untreated plots has been very poor for several years, indicating that where all crops are removed rotation alone is not effective in keeping soil sufficiently productive for good burley tobacco.

Judging by the general appearance and quality of the tobacco grown in the rotations, it seems evident that continued production of good quality burley in short rotations is rather difficult and that probably it can not be accomplished without liberal use of manure, plowing under legume crops or heavy fertilization with commercial fertilizers. Undoubtedly the effects of rotation are complicated by the effects of disease in these short rotations. In previous reports, it has been stated that the tobacco grown after alfalfa in these rotations, even when manure was used, was inferior in quality. Lime has not been used since 1926 and the quality of tobacco has greatly improved on these plots. In 1931 it was as good as the manured orchard grass plot which had previously produced the best quality of leaf. The yield also was good.

Tomatoes. The study of the effect of maintaining different nitrate, phosphate and potassium levels in the conducting tissues of the tomato plant, on growth and yield, has been continued. The different levels in the plant were maintained this year, not only by the use of different treatments on a uniform soil, but also by using soil of several different types and by diluting a certain soil with sand. The different soils produced surprisingly different ratios and levels of nitrate and phosphate in the petioles of the tomato plant. The results indicate that determination of the levels of nutrients in the conducting tissues of the plant affords a very definite gauge of the ability of the soil to supply the proper nutrients for plant growth. In fact, this procedure appears to be more significant and rapid, for this purpose, than determination of the solubility of nutrients in the soil, by the methods of soil analysis now in common use. In the plant tests, no assumptions have to be made, since the nutrients found in the conducting tissues are actually the nutrients available to the plant. Furthermore, the optimum nutrient levels for each plant may be determined which will be independent of soil differences and will afford a definite guide for fertilizer applications on all types of soil.

In order to make practical application to field crop production it seemed necessary to develop tests that were rapid and accurate so that deficiencies could be corrected in time to influence the crop. The attempt to develop field tests for tomatoes was successful and probably can be perfected for testing other crops. These tests included the quantitative determination of nitrate, phosphate and potassium in tomato tissue in the field. It requires about half an hour to make all three tests in duplicate. The phosphate test can be completed in ten minutes and is very sensitive for a rapid method. A difference as low as 5 ppm. may be detected readily in extracts of low phosphate concentration. The nitrate test detects differences as low as 10 ppm. in low nitrate extracts. The potassium test is not so sensitive. The principal reagent for nitrate is phenoldisulfonic acid; for phosphate, 1-2-4 amino-naphthol-sulfonic acid; and for potassium, sodium cobaltinitrite. Plants that showed defi-

ciencies in nutrients by these tests were treated with fertilizers. The plant response was quite satisfactory. The tests were especially valuable in indicating nitrogen and phosphorus deficiencies.

Results are not complete in the study dealing with the effect of organic matter, sodium carbonate and alkali on non-symbiotic nitrogen fixation, nitrification and the growth of the tomato. When enough alkali was added, with straw, to increase the pH of an acid soil to 7 or more, nitrification was enhanced, but if the pH is lower than this the large carbon-nitrogen ratio results in a large reduction of nitrification. The growth of the tomato plant was largely determined by the nitrification, the result being very poor, sickly plants when the pH was below 7, but medium, large, fruitful plants when the pH was above 7. These results seem to point to the value of alkali treatment when a large amount of strawy organic matter is used. Field tests on the use of strawy organic matter and alkali treatments were inconclusive, probably because of the washing caused by heavy rains in July.

Group Planting of Tomatoes. A preliminary test was made, comparing the planting of tomatoes in groups, in the field with planting in rows at regular intervals, as is the common practice. The purpose of the test was to find a method of preventing loss of fruit from sunscald and from rotting caused by contact with the soil. The group plantings consisted of 6 plants set in an area 2 x 3 feet, with a space of 4 feet between groups. A 4-foot stake was driven in each corner of the group and twine was tied from stake to stake at suitable heights to hold the vines off the ground. The vines were not pruned or tied. The plants in the plot planted by the usual method were set 3 feet apart in rows 6 feet apart.

The group method of planting resulted in a 50 percent increase in the yield during June and July, and 13.9 percent for the entire season. The losses from sunscald, cracking and soil rot in the group plot ranged from about 20 to 30 percent, while the losses in the plot planted in the usual manner ranged from about 70 to 80 percent. The close planting in the groups pro-

vided sufficient shade to reduce the damage due to sunscald and cracking and there was a marked reduction in rot where the fruits were kept off the ground. The results indicate that the group plan of planting may have considerable value for the market gardener because of the large increase in the percentage of sound fruit early in the season when prices are relatively high. Further work will be necessary to determine whether the profits from the use of the group plan will offset the additional labor, plants, stakes and twine required when the crop is grown on contract for canning companies.

Vegetable Variety Tests. Forty-five varieties of vegetables were grown for testing. Money Maker sweet corn was worthy of note. The yield was practically double that of any other variety in the test. Altho it is white, and only moderate in quality, it appears promising as a market garden variety. The World Beater pepper appeared to be outstanding. The yield was good and the fruits uniform in size and shape. As a home garden variety, the Japanese eggplant appeared to be distinctly superior to the Black Beauty which has long been the popular variety. The fruits were of a medium and more satisfactory size and matured a succession all thru the summer, while the Black Beauty produced very large fruits at irregular intervals. Of the varieties of tomatoes tested, the Pritchard produced the largest total yield of marketable fruit thru the season, while Break O'Day and Landreth made a high yield early in the season. Compared with Marglobe, these varieties suffered much less from cracking and defective fruit. Break O'Day and Pritchard are wilt-resistant.

Soil Experiment Fields. The plans of the Lexington soil experiment field were radically changed at the end of the cropping season of 1931, twenty-one years after work was begun on it. Before the change the rotation used was corn, soybeans, wheat and clover. Lime, phosphorus and potassium had no appreciable effect on crop yields, whether used singly or in various combinations, except for a slight effect on clover. The return, for twelve years, of crop residues consisting of cornstalks, wheat straw and soybean straw, had no appreciable effect

on crop yields except for a slight effect on clover. The use of manure on corn increased the yield about 7 bushels per acre and increased the yield of clover about 650 pounds per acre but did not increase the yield of soybeans and wheat.

The present rotation is corn, wheat and alfalfa for two years. Alfalfa seeded in the summer of 1931 showed a marked response to potash, whereas the crops in the former rotation failed to respond significantly. As an average of twelve tests, potash increased the yield of alfalfa 1000 pounds per acre for two cuttings, where the yield was 3 tons without potash.

The value of good soil management and the importance of lime and phosphate are again shown in the results from the various outlying soil experiment fields, a tabulation of which is given:

Field	Corn, Bus.			Wheat, Bus.			Grass and Legume Hay, Lbs.		
	O	M	MLP	O	M	MLP	O	M	MLP
Berea	4.9	15.7	42.3	No wheat grown			000	000	3570
Fariston	*Sorghum			3.0	3.3	11.8	640	640	3800
Campbellsville	15.6	27.7	60.9	0.3	2.8	6.9	1320	2760	3420
Greenville	10.6	28.1	56.6	2.3	7.2	14.7	840	740	2290
Mayfield	33.4	47.9	52.9	8.2	8.0	14.7	600	1100	3620
Average	16.1	29.9	53.0	3.5	5.3	12.0	680	1048	3340

*As in the previous year, sorghum was substituted for corn at the Fariston field in order to study the effect of various soil treatments on the yield and quality of sirup. Thirty gallons of sirup were produced per acre of sorghum treated with manure alone; 114 gallons from that treated with manure, limestone and superphosphate, and 143 gallons per acre of sorghum treated with manure, limestone, superphosphate and potash. In addition to the better yields from the use of limestone and fertilizers, the quality of the sorghum was greatly improved.

On the Berea, Greenville and Mayfield fields, plots that had been treated with superphosphate and rock phosphate from the beginning of the experiments in 1913, were divided in 1931. The applications of phosphate were continued on one half of the plots and omitted from the others. Approximately 3000 pounds of superphosphate and 6000 pounds of rock phosphate per acre had been applied in 18 years.

At the Berea field, as an average of two years for three comparisons of the two phosphates, corn with and without the use of phosphates produced practically identical yields, the extreme variations being from 46.1 to 47.0 bushels. The same was practically true for one crop of soybeans following corn and for a crop of mixed grass, clover and alfalfa following soybeans.

At the Greenville field, wheat was apparently reduced about 3 bushels per acre by the omission of superphosphate, but there was no reduction from the omission of rock phosphate. The yields from the use of rock phosphate were one half bushel less than those from the use of superphosphate. The yield of grass and legume hay was 700 pounds less per acre where superphosphate was omitted than were applied, while the difference for rock phosphate was only 65 pounds. The yield with superphosphate applied was 330 pounds more per acre than with rock phosphate omitted.

At Mayfield, the yields of two crops of wheat were 1.4 bushels better per acre where superphosphate was used than where it was omitted, whereas the omission of rock phosphate did not reduce the yields. Grass and legume hay was about 600 pounds less per acre from the omission of superphosphate. The yield from the omission of rock phosphate was as large as where it was applied. The results of these tests up to the beginning of the omission of phosphate are set forth in Bulletin No. 322.

In 1929, a change was begun in the tobacco rotations on the experiment fields, from tobacco, wheat and clover to a 6-year rotation of tobacco two years, wheat, clover and bluegrass mixture for three years. On the Campbellsville, Greenville and Mayfield fields, excellent bluegrass sods have been produced in three years that rival those of the better Central Bluegrass Region. The best sods were on soil treated with limestone and phosphate, but good sods were produced on soil treated with phosphate. At Princeton, bluegrass sown with alfalfa produced an excellent sod in six years. These results have very great significance for Kentucky soils outside the natural bluegrass area.

Mixed grass and legume (clover and alfalfa) were grown this year at Mayfield and Greenville on soil that was limed at the rate of 2 tons per acre in 1913 and again in 1917, with screenings of $\frac{1}{4}$ inch and finer. The improvement that has come from these applications resulted in an increased production of hay in 1932 of approximately 1700 pounds per acre at Mayfield and 500 pounds at Greenville. From the outset of the tests, lime has been much more effective on the soils at Mayfield than at Greenville.

Renewed Fertilizer Experiments. These experiments were re-established in 1915 on plots that had been used for fertilizer experiments from 1888 to 1898 and that had been in bluegrass in the interim. In the renewed tests, the same fertilizer treatments were used as in the old tests. In the old tests, corn was grown continuously and removed, without a cover crop. In the renewed tests, corn was grown in the same way on one series of plots, and on another series of plots, fertilized the same as in the old tests, a rotation of corn and soybeans was used, with the cornstalks and soybean straw returned and a winter cover crop of rye. The average yield of corn (alternate years) from 1915 to 1927 in rotation was 53 bushels on unfertilized plots and 58 bushels for the best fertilized plot. In continuous culture the average yield was 37 bushels on unfertilized plots and 50 bushels on the best fertilized plot. After having both series in grass and clover for two years, the average yield for the series that had been in rotation was 56 bushels, while for the continuous-culture series it was 44 bushels. Both series produced identical yields in preliminary cropping the year before the tests were renewed. These renewed experiments were discontinued with the close of 1931.

Liming Experiments. A rotation of corn, wheat and a mixture of legumes is being used in a test of different rates of liming and the use of limestone of different degrees of fineness. A summary is given of the results on five hay crops and four corn crops following the hay crops (corn crop of 1930 was a failure on account of drouth). All plots were treated with superphosphate and potash.

	Increases	
	Corn, Bus.	Hay, lbs.
1 ton limestone	12.8	960
2 tons limestone	9.9	2,055
Average of 6 tests with $\frac{1}{3}$ ton of limestone or equivalent of hydrated lime	9.0	1,010
Average, 250 lbs. limestone and 250 lbs. hydrated lime	5.5	636

The different grades of fineness of limestone were 10-20 mesh, 40-50 mesh, 70-80 mesh, 100 mesh and finer. There was no consistent difference in the effectiveness of the different degrees of fineness, nor was there any consistent difference in the effectiveness of limestone and the equivalent of hydrated lime. The one- and two-ton applications were made at the beginning of the work; the small applications were made with the wheat preceding each legume crop. Three hay crops were grown following a first application of one-third of a ton of ground limestone and two were grown following a second similar application. These results are of much significance to the farmer who can not use the larger applications of limestone.

Rate-of-Liming Experiment. The second round of the rotation started this year. Tobacco appeared for the second time on the same series of plots. The effects of the very heavy applications of limestone on growth and characteristics of the tobacco were still apparent, but were not so marked as in previous years. Probably this may be largely accounted for by seasonal conditions.

Corn yields continued considerably less on the very heavily limed plots than on those receiving light and moderate applications. The large decreases occurred on the plots treated with 10, 20 and 50 tons of ground limestone per acre. Clover and wheat yields were also reduced on the heavily limed plots. The yields of corn, wheat and clover for 1932 were:

Amount of Limestone, Lbs. Per Acre	Corn, Bus. Per Acre (Field wt.)	Wheat, Bus. Per Acre	Clover Hay, Lbs. Per Acre (Field wt.)
500	62.3	35.3	6320
1,000	68.6	32.0	6320
2,000	70.9	29.7	6340
4,000	68.6	30.0	6080
10,000	67.4	26.0	5920
20,000	58.3	27.3	5600
40,000	60.0	25.3	4920
100,000	55.3	26.0	4760
None	66.0	29.7	6493

Phosphorus Availability. Investigations at other experiment stations have shown that the low crop yields obtained from combined limestone and rock phosphate treatments may be due to the depressing effect of the large amount of calcium in the two materials on magnesium availability for crop use. A greenhouse pot experiment was carried out to obtain information on this point for the experimental soil field at Campbellsville. Soil from two plots was used, on one of which applications had been made amounting to 4000 pounds per acre of rock phosphate since 1919, and on the other the same treatment plus 4 tons of ground limestone. Crop increases in the field have been considerably less from the combined treatment than from rock phosphate alone, particularly of red clover. Soil from both plots was used (1) with a treatment of magnesium sulfate at the rate of $1\frac{1}{2}$ gram per 3,200 grams of dry soil and (2) without this treatment. Red clover was grown and harvested twice. The experiment was run in triplicate. The average oven-dry weight in grams of clover harvested per pot was:

Soil from rock phosphate plot	{	no magnesium treatment	23
		treated with magnesium sulfate	23
Soil from rock phosphate and ground limestone plot	{	no magnesium treatment	17
		treated with magnesium sulfate	15

Breeding for Corn Yield. Sixty single and double crosses from the selfed strains produced at the Experiment Station were tested in 1932. In addition, the test included a number of crosses of selfed strains and single crosses with open pollinated varieties. The favorable season for corn and the large number of crosses available for testing made it possible to obtain much

information regarding the value of the various strains which have been selfed at the Station for from 8 to 12 years. As was expected, only a limited number of crosses were outstanding in yield. These were single crosses and crosses of single crosses and selfed strains with open-pollinated varieties. Among the double crosses there was none that gave an exceptionally high yield. In some instances, however, the quality, that is the soundness of the corn, was much better than that of the ordinary open-pollinated varieties. The best single crosses not only gave a high yield, but the corn was almost free from disease. This soundness was especially noticeable, as rot caused much damage to the 1932 corn crop.

Diseases of Red Clover. In connection with a study of the causes of clover failure in Kentucky, various diseases contributing to failure of unadapted clovers have been studied. Adapted Kentucky clovers were found to be less injured by crown-rot caused by *Sclerotinia trifoliorum*, loss of plants in second-year clover occurring to the extent of only 25 percent, whereas plants of unadapted clovers were reduced under comparable conditions as much as 80 percent. Infection was general over the entire field, for the following fall apothecia of *S. trifoliorum* were found in more than 95 percent of 156 random square-foot areas examined, with an average of 26 apothecia per square foot. Ascospores of *S. trifoliorum* infect red clover plants in the fall directly thru the uninjured surface of the leaves and petioles. In a field where apothecia are abundant, leaflets may be heavily peppered with small brown specks from which *S. trifoliorum* can regularly be isolated. When these leaves die during the winter, the fungus is released and rot develops. This disproves the commonly accepted theory that this organism first has a long saprophytic stage before attacking clover plants.

The cause of black stem of red clover and alfalfa was found to be species of *Phoma*, while that of sweet clover was found to be *Mycosphaella lethalis* Stone. The organisms overwinter on dead shoots of these plants. No perfect stage was found to be genetically connected with the species of *Phoma*. The disease caused extensive injury to alfalfa in the early spring. Some

stands were practically destroyed by the disease. Two sterile fungi were isolated from red clover leaves, each of which was found by inoculation to be the cause of a clover leaf-spot. One of these practically destroyed a stand of subterranean clover. The organism causing the disease known as Southern anthracnose was isolated several times from crowns of red clover plants which were dying. *Rhizoctonia solani* was isolated after the middle of August from crowns of spring-sown red clover plants which were wilting. *Sclerotium bataticola* was isolated from the rootlets of red clover during the winter and summer and from dead crowns of red clover from the greenhouse and field. The organism was found to be mildly pathogenic on clover seedlings grown in culture dishes and in soil.

A virus disease of red clover corresponding closely in its symptoms to yellow ringspot of tobacco was found affecting red clover plants growing in a row adjacent to tobacco plants affected with yellow ringspot.

Kentucky Bluegrass. The residual effects of sweet clover, white clover, red clover and lespedeza on the yield of bluegrass in which they had grown three years previously produced approximately 30 to 80 percent more than bluegrass which had no companion legume. The largest increase followed red clover. An application of 200 pounds of nitrate of soda to the acre during the middle of April was no more effective than the residual effect of red clover. These results indicate that a frequent legume crop in a bluegrass sod is as effective in maintaining productiveness of bluegrass sods as moderate applications of nitrogenous fertilizers, and that it is an important item in proper economic pasture management.

Sorghum. Twelve varieties of sweet sorghum, five of which are grown locally in eastern Kentucky, were given a plot test for the purpose of studying the quality of the sirup produced. The quality varied widely with the variety. Seven of the twelve varieties, four of which are Kentucky varieties, produced second- or third-grade sirup. It is quite evident from this study that much low-grade sorghum sirup is the product of inferior varieties.

Orchard Cover Crops. An apple block upon which no fertilizer was used in 1932 but which had a winter cover crop of barley, was cultivated in the spring and sown to millet about June 1. The trees made a markedly better growth than those on the plots in sweet clover, lespedeza and bluegrass sods, respectively. This result seems to indicate that in periods when cash expenditures for fertilizers must be reduced to a minimum because of economic circumstances, good tree growth may be maintained by spring cultivation and the use of quick-growing non-leguminous crops which make a large volume of vegetative matter for turning under. Altho this procedure would not be expected to result in the actual improvement in soil fertility that may be obtained thru the use of legume crops and commercial fertilizers, as commonly practiced by many growers, yet it does appear to provide a method of maintaining satisfactory tree growth without seriously depleting soil fertility, and with little cash expenditure. It is believed that such a plan of orchard management may have wide application at this time.

Summer and Winter Cover Crops for Peach Orchards. For the third consecutive year rye used as a winter cover crop for peaches has been allowed to grow to the early blooming stage before being disked under. No shock to the trees has been noted as a result of disking under the heavy stands resulting in the manured plot, or the thinner stands on unmanured plots. The cover thru the winter and the amount of organic matter turned under in the spring were greatly increased by applying to the rye cover crop in the fall the nitrogenous fertilizers which would ordinarily be applied to the trees. The use of rye and fertilizers in this way makes it possible to turn under a heavy cover crop in orchards in which the soil is so poor that it is nearly impossible to obtain a stand of any of the other winter covers.

Orchard Spraying Tests. Russetting of fruit, which is usually attributed to the action of the spray material used, was found to occur on unsprayed trees. Fourteen and eight-tenths percent of russet was found on certain varieties of apples and must be attributed to weather or causes other than spraying. One result

of the spraying tests stands out conclusively, namely, that examination of the spores of apple scab is not a safe index for timing sprays for the control of this disease. During mild rainy periods, the spores matured rapidly and infections occurred before the weather permitted sprays to be applied.

Leafhopper Studies. It has been recommended generally to cut alfalfa infested with leafhopper, when the plants become stunted and yellow, but if this is done before the hoppers are most abundant, the third or later cuttings are likely to be injured. In Fayette County, the hoppers are most numerous during the last week of July or a few days later and the decline in numbers is rapid after that time.

During the season of 1932, spring-sown alfalfa was grown under cages and leafhoppers were placed on the alfalfa in one-half of the cages; the alfalfa in the remaining cages was not infested and served as checks. The cages were arranged for six separate tests and the first cutting of the alfalfa for each test was made on a different date, namely; July 11, 16, 21, 25, 28 and August 1. The second cutting for each test was made 45 days after the first cutting in every test. The recovery or growth of infested alfalfa after cuttings made July 11, 16 and 21 was not so good as where the cuttings were made July 25, 28 and August 1. This is explained by the fact that the hoppers had greatly increased in numbers on the new growth of the earlier cut alfalfa and that the later cuttings were made at the peak or decline in numbers of hoppers. The difference in the amount of recovery or growth after the cuttings is shown by the difference in the weight of infested and check plots which were cut July 11 and August 1. The plots cut July 11 were cut again on August 25 and the infested alfalfa weighed 55.2 percent as much as the check. The plots cut August 1 were cut again September 15 and the infested alfalfa weighed 68.4 percent as much as its check. The tests indicate that alfalfa makes a better growth or recovery from leafhopper injury after July cuttings than after cuttings made earlier in that month. These tests were made on alfalfa of one season's growth and the

injury was more severe than for older plants. The experiments should be repeated another season on older plants before definite recommendations are made. The cutting dates July 11, 16, 21, 25, 28 and August 1 are here called first cutting dates, but they would represent second cutting dates for alfalfa of more than one season's growth.

Codling Moth and Spray Studies. Recommendations for spraying were based on studies made both in the field and at the insectaries located at Henderson, Louisville and Paducah. An important feature of the spray service to the fruit growers has been the introduction of the tank-mixed emulsion. Water with different degrees of hardness behaves differently in the mixing tank. Laboratory tests were conducted to determine the procedure in the various sections of the state. A leaflet giving direction for the preparation and use of this material has been published. Because of the very low cost of this material, it is being promoted vigorously by the horticultural interests in practically all sections of Kentucky where fruit is grown on a commercial scale. This information, if applied, will save the fruit growers of Kentucky many thousands of dollars during the next few years.

The use of "topping," a new spray practice in Kentucky, has proved practical and has been adopted by most of the commercial fruit growers in the state. This practice of replenishing the poison in the tops of trees after a relatively short period of weathering and following rains and storms, is especially important, as much of the codling moth activity is in the top of the tree.

Tests at the spray service centers have shown that adhesives are valuable and necessary in increasing the effectiveness of lead arsenate in codling moth control. In blocks of trees sprayed with fish oil as an adhesive, the poison was killing codling moth larvae effectively six weeks after the last application and probably continued to do so for a longer period, altho check areas where the adhesive was not used were losing their effectiveness in approximately two weeks. In studying the action of adhesives,

it was found that fish oil of the proper specification did not mix with all kinds of lead arsenate, whereas raw linseed oil mixed uniformly well with all kinds of lead arsenate. Also, it was found that the dosage of lead arsenate could be reduced when adhesive was used and that the control would still be more effective than when lead arsenate was used at normal dosage without adhesive.

Lead arsenate has caused injury to peach trees in practically all the orchards in Kentucky where its use was observed. The addition of hydrated lime reduced the injury somewhat, but damage has been observed with practically all proportions of lead arsenate with hydrated lime from the 1-1 mixture up to and including the 1-10 dilution. It was observed very definitely that peach trees were least injured when they were in good productive vigor. Records for the last two years show that trees which were not pruned and which were not provided with a well-balanced food supply were seriously injured even with one application of lead arsenate. Where zinc-sulfate and lime hydrate were used in an attempt to control bacterial leaf-spot, the amount of injury from the arsenic was very greatly reduced and often nearly eliminated.

The use of parasites is becoming more and more important each year in efforts to combat injurious insects. This year, a number of colonies of *Trichogramma minutum*, an egg parasite on the codling and Oriental fruit moths, have been developed and released in apple orchards of the state. Also, in cooperation with the United States Department of Agriculture, seven colonies of *Macrocentrus ancylovora*, a larval parasite of the Oriental fruit moth were released in peach orchards of the state.

Raspberries. It was found that strong canes in the hill area can be influenced by attention in the early spring when the young suckers are 3 to 4 inches tall. If a sufficient number of suckers appear in the hill area, selection should be made at this time and all other suckers kept hoed off as they appear. However, if the suckers appear outside the hill area, it was found that cutting them off when the first ones are 3 to 4 inches tall, in-

creased the tendency to send up suckers in the hill area. If the suckers were allowed to make considerable growth before being removed, there was difficulty in obtaining strong canes in the hill area.

The use either of nitrate of soda or sulfate of ammonia resulted in marked stimulation of growth. The effect on production will be noted next season.

The varieties of red raspberries receiving the most attention among growers are the Latham and the Chief. The Latham seems to be well established, but the Chief is too new to draw definite conclusion as to its adaptability and value in Kentucky. As grown on the Experiment Station farm, the Chief is less vigorous than the Latham, the fruit ripens a week to ten days earlier and is smaller in size, but better in quality. The yield has not been equal to that of the Latham.

Because of the practice of some dealers to sell plants without grading them, it is of importance to plant buyers to know that vigorous, well-rooted black raspberry plants proved markedly superior as compared with small, poorly rooted plants. The poorly rooted plants resulted in a poor stand and little growth was made by those that lived.

Nursery Inspection. Two of the major troubles observed in the nurseries this year resulted from much winter injury on evergreens and the use of old ground. The principal insects and diseases found in the nurseries were, on apple, scab, leafhoppers and San Jose scale; on peach, leafhoppers and flea beetles; on strawberry, white grub, crown borer and leaf roller; on raspberry, leaf spot; on evergreens, bagworm, red spider and galls; on deciduous ornamentals, cankers on poplar and willow, leaf-spot on poplar and willow, scale on mountain ash and red spider on maple. One hundred and thirty-nine inspections were made. Certificates issued since July 1 include 67 resident, 98 non-resident, 22 agent's and 27 dealer's permits.

Seed Inspection. A new pure seed act was passed by the General Assembly of 1932. This became effective July 1. Much time has been given in acquainting farmers, seedsmen and

others with the provisions of the law. From July 1 to May 1 more than 2,000 seedsmen in the state have been visited personally and about 1,500 inquiries relative to the seed law answered by letter or telephone. Analysis has been made of 7,263 samples of seed. Tests for purity numbered 3,732; for germination, 5,296. The samples included 1,428 grasses, 2,792 clovers; 79 vegetables, and 580 large seed. Tests were made of 1,596 samples of tobacco seed and 1,501 pounds of tobacco seed were cleaned.

Creamery License. Following the adoption and putting into operation of more comprehensive regulations governing the sampling and testing of milk, a relatively greater amount of time has been devoted to the inspection of sampling and testing at milk plants, condenseries and cheese factories. The increasingly large volume of milk bought on butterfat content makes this work important. It was found that improper methods were commonly in use. Such cases were handled according to the grading system and in each instance recommendations were made for correcting conditions.

Partly churned or sour composite milk samples were found in several instances during the summer. Investigations were made in the laboratory to determine the effect of high temperature, refrigeration and varying amounts of preservatives in obtaining accurate composite samples. Three trials, each consisting of twenty 10-day composite samples, were made. From the results obtained it was concluded that (a) composite samples should not be allowed to remain at high temperatures; (b) the usually recommended maximum amount of preservative is sufficient to prevent souring (1% solid preservative by weight, or two drops per ounce liquid); (c) refrigeration of samples is beneficial; (d) composite samples properly preserved will not churn unless agitated excessively.

Inspections totaled 431, including 6,686 individual tests. Of the inspections made, 364 were graded A, B and C (excellent to mediocre) 54 were graded D, placing the operators on probation, and 13 graded E, making it necessary to call the operators

before the Examining Board. Because of inaccuracy or of not being inspected and stamped, 75 pieces of testing equipment were condemned. Inspection was made of 15,027 pieces of glassware sent in by manufacturers. Of this number, 14,863 pieces were stamped as meeting the requirements of the law, and 164 pieces were rejected as being below standard or inaccurate.

The Examining Board met twice during the year and considered 13 cases of unsatisfactory testing and violation of regulations. Licenses were revoked in four instances; refusal of reinstatement in six, and two testers and one buyer were placed on strict probation with provision that their licenses would be revoked following an unsatisfactory inspection. In addition, the permits of two operators were recalled for unsatisfactory testing and two buying places were ordered closed for violation of regulations.

Licenses authorizing their holders to buy milk and cream on the basis of the butterfat content for the period ending June 30, 1933, were issued to 12 creameries, 4 cheese factories, 6 condenseries, 48 milk plants and ice cream manufacturers, 38 independent operators of cream stations and 839 cream stations operated by creameries, a total of 947. Of this number, 908 were renewal licenses and 39 for new buying places beginning operation since June 30.

There are now 1,041 authorized testers in Kentucky, 874 of whom hold renewal licenses granted July 1, 1932; 85 are new operators licensed since that date and 82 are operating on permits. Twenty-four examinations for applicants for tester's license were held as follows: Louisville 3; Lexington 4; Bowling Green 4; Paducah 1; Owensboro 2; Cincinnati 2; Falmouth 1; Maysville 2; Special 5. Notification of examination was sent to 361 persons, 214 of whom appeared. A passing grade was made by 204 of those who took the examination.

The receipts for the year were \$8,587.08 and the expenditures \$9,317.91, as itemized:

Salaries	\$7,959.17
Labor	98.08
Postage and stationery	269.07
Freight and express	12.17
Sundry and laboratory supplies	47.50
Travel	907.92
Contingent	24.00
Total	\$9,317.91

Feed Control. A decline in the consumption of commercial feedstuffs occurred during the year despite their cheapness and the increased number of livestock over 1931. Prices of grain, hay and by-product feeds were at an unusually low level for the year, as were the prices of products into which these materials are converted. Feedstuffs of all classes were the cheapest in many years. On the basis of the tax tags issued, the feed consumed in Kentucky for the year is estimated at 132,000 tons, about half the amount of the preceding year.

Analysis has been made of 1,153 samples of commercial feedstuffs. Of this number, 134 were analyzed for consumers and dealers and 154 for miscellaneous purposes, such as research work, check analyses, etc.

Five state cases were filed for prosecution. Four of these have been decided in favor of the department of feed control, and one is pending. No federal cases were filed during the year, but the decision in seven of the cases filed in 1931 was in favor of the department.

Two new problems have entered into the feed control work. They are not easy of solution. One is the batch-mixing and the other the portable mill. No adequate or satisfactory plan has as yet been devised to handle them.

Fertilizer Control. Seven hundred and twenty brands of fertilizers were registered, for which 1,590,000 tags were issued. Analyses were made of 555 samples of fertilizer submitted by farmers and inspectors. The results of these analyses are published in Bulletin 336.

Public Service Laboratories. Examination was made of 105,857 samples, which is 11,062 more than were examined last year. A total of 1,376 physicians, nurses, hospitals, clinics, city and county health departments submitted work of a public health nature. Eighty-one county health departments or health units submitted work during the year. This is the largest number in the history of these laboratories and is largely responsible for the increase of work indicated.

The bacteriological laboratory handled 104,395 of the total samples submitted. This required the making of 40,376 Wassermann tests; the examination of 6,989 samples of water and dairy products, and of many specimens for tuberculosis, diphtheria, gonorrhea, malaria, typhoid, rabies, hookworm and other parasites, mold, yeast, bacteria, etc., etc.

In the food laboratory, 1,226 samples of food were examined for adulteration and deficiency. These samples comprised milk, cream, butter, cheese, frozen dairy products, canned goods, meat products, cereals, etc.

A tabulation of the work conducted in the drug laboratory shows 98 official drug samples, 85 poison investigations, 27 sanitary and chemical examinations of water, 2 prohibition cases and 24 miscellaneous samples, a total of 236.

Personnel. The staff of the Experiment Station is shown on page 3 of this report. The appointments and resignations for the year follow:

Appointments:

George S. Terry, bacteriologist, department of public service laboratories, January 4.

E. A. Baute, field agent in poultry improvement, February 1.

Resignations:

Genevieve Farwell, technician, department animal pathology, March 31.

Fred Boyd, assistant in rural life studies, (substitute member of staff) department of farm economics, June 16.

New Projects:

Virus disease of the peach and plum.

- The control of spur-blight, caneblight and other fungus diseases of raspberry affecting the canes.
- A study of the clover-root curculio, *Sitones hispidula*, and its relation to clover and alfalfa failures.
- A study of various stages of growth of strawberry plants for setting.
- Raspberry planting and training.
- Marketing sorghum molasses in Kentucky.
- Rate-of-liming experiments.
- Delayed conception and sterility in heifers.
- Economics of hog production in Kentucky.
- Effects of outcrossing Rhode Island Red chickens.
- The germicidal effectiveness of certain chlorine compounds on some micro-organisms commonly associated with milk.
- A comparison of finishing yearling steers in the dry lot and on pasture.

Publications:

Bulletins:

No.

326. Forestry in the economic life of Knott County, Kentucky, Ronald B. Craig, February, 1932.
327. 1. Seed transmission and sterility studies of two strains of tobacco ringspot. 2. A virus disease of delphinium and tobacco. 3. A virus disease of plum and peach, W. D. Valleau, February, 1932.
328. Tobacco diseases in Kentucky, W. D. Valleau and E. M. Johnson, March, 1932.
329. The resistance of certain red clovers and alfalfas to leaf-hopper injury, H. H. Jewett, June, 1932.
330. Commercial feeds in Kentucky in 1931, J. D. Turner, H. D. Spears, W. G. Terrell and L. V. Amburgey, June, 1932.
331. Soils and fertilizer experiments, Experiment Station Farm, Lexington, George Roberts and E. J. Kinney, July, 1932.
332. I. Winter versus summer feeding of corn to heavy steers finished on grass. II. Wheat as a fattening feed for yearling steers, E. S. Good and W. J. Harris, July, 1932.
333. Infections of fetuses and foals, W. W. Dimock and P. R. Edwards, August, 1932.

334. The comparative effect of muriate and sulfate of potash on the composition and quality of white burley tobacco, P. E. Karraker, October, 1932.
335. The pH of fresh and storage eggs, S. E. Erikson, R. E. Boyden, J. Holmes Martin and W. M. Insko, Jr., November, 1932.
336. Analyses of commercial fertilizers, H. E. Curtis, H. R. Allen and Lelah Gault, December, 1932.

Scientific Papers:

- Apple scab spore development and scab spray, W. D. Valleau, Transactions of Kentucky Horticultural Society, 1932.
- Effect of boron on the growth of lettuce, J. S. McHargue and R. K. Calfee, Plant Physiology 7:161-164, 1932.
- Determination of iodine in soils, J. S. McHargue, D. W. Young and W. R. Roy, Industrial and Eng. Chemistry, Analytical ed. v. 4, p. 214, 1932.
- The iron, manganese, copper, zinc and iodine content of some important forage crops, J. S. McHargue, W. R. Roy and J. G. Pelphrey, Jour. Amer. Soc. Agronomy, v. 24, No. 7, July, 1932.
- The determination of boron spectroscopically, J. S. McHargue and R. K. Calfee, Industrial and Eng. Chemistry, Analytical ed., v. 4, p. 385, Oct. 1932.
- Manganese essential for the growth of *Lemna major*, J. S. McHargue and R. K. Calfee, Plant Physiology 4: 697-703, 1932.
- The effects of magnesium carbonate when added to diet of growing chicks, G. D. Buckner, J. Holmes Martin and W. M. Insko, Jr., Poultry Science, v. xi, No. 1, p. 58, Jan. 1932.
- The comparative methods of calculating the rates of growth of experimental animals, G. Davis Buckner, W. M. Insko, Jr., and J. Holmes Martin. Read before the 19th annual meeting of the Ky. Acad. Sc. Apr. 28, 1932.
- Effect of confinement on the growth of chicken combs and testes, G. Davis Buckner, W. M. Insko, Jr., and J. Holmes Martin, Am. Journ. Physiology, v. 102, No. 2, Nov. 1932.
- Effect of frequent turning on hatchability and distribution of embryo mortality, W. M. Insko, Jr., and J. Holmes Martin. Presented at 24th annual meeting Poultry Sc. Assoc. Abst, Poultry Sc. v. xi, No. 6, Nov. 1932.
- The biochemical characters of human and animal strains of hemolytic streptococci, Philip R. Edwards, Jour. Bact. v. 23, pp. 259-267.

Estimation of reducing sugar by colorimetric determination of un-reduced copper, E. M. Emmert, Jour. A. O. A. C., v. 15, No. 2, pp. 327-9, May 15, 1932.

A variant occurring naturally in cultures of *Salmonella pullorum*, Philip R. Edwards, Jour. Amer. Vet. Med. Asso., v. 80, pp. 891-5, 1932.

The identity of streptococci of animal origin with certain strains of *Str. epidemicus*, Philip R. Edwards and W. W. Dimock, Science, N. S. v. 76, No. 1961, pp. 137-8, July 29, 1932.

Cattle as a possible source of infection from *Brucella abortus suis*, Amanda Harms, Jour. Amer. Vet. Med., Asso., v. 81, N. S. 34, No. 2, pp. 246-9, Aug. 1932.

Field method for estimating nitrate, phosphate and potassium in plants, E. M. Emmert, Plant Physiology, v. 7, pp. 315-21, 1932.

Rough and smooth variety of *Shigella equirulis* (*B. nephritidis equi*), Philip R. Edwards, Jour. Bact. v. 24, p. 283, 1932.

The serological characters of *Shigella equirulis* (*B. nephritidis equi*), Jour. Infect. Dis., v. 51, 268, 1932.

The mineral and nitrogen content of the leaves of some forest trees at different times in the growing season, J. S. McHargue and W. R. Roy, Botanical Gazette, v. 94, No. 2, pp. 381-93, Dec. 1932.

ROBINSON SUBSTATION.

Meetings. Four well attended meetings were held during the summer and autumn. These included the conference for county agricultural and home demonstration agents and club leaders of eastern Kentucky, July 6-8; the fifth annual camp for farm women, July 18-22, which had representatives from eight counties and a larger attendance than in any of the previous years; the 4-H boys and girls' camp, August 1-5; and the Robinson Harvest Festival, September 29-30. The Robinson Harvest Festival was inaugurated seven years ago and has become an outstanding annual event of Eastern Kentucky. Each year it grows in interest and popularity, as is shown by the attendance and number of exhibits.

Forestry. A few of the recent plantations of young trees were cleaned of briars and other brush. Most of the older plantations are now at a point where they require little care of this

kind. An attempt has been made to arrange the checkings of the plot into the first, second, fifth, tenth, etc. years. In the majority of cases, the first and second years have passed with no record, but in many instances the fifth year can be recorded. On that basis, those having passed their fifth season this year were checked for survival and height. Also, these plots were staked with 18" chestnut stakes so that in succeeding checks the same individuals may be measured. The plots of introduced chestnuts were again checked. Only very few showed a good sturdy growth for the year. No signs of the chestnut blight were observed.

Facilities for the location of fires were greatly increased by the extension of the telephone lines and the addition of two towers. One telephone line connects the forest headquarters with the toll line and is approximately $6\frac{1}{2}$ miles in length; the second, a little more than six miles long, is an extension, with branches, of the line already in use from forest headquarters. The lookout towers are each 25 feet in height and built of chestnut poles and rails. One was erected on Coles Fork and the other at the head of Twin Hollows of Laurel Fork.

Recutting and painting of the boundary line was started in June. The main tract is completely cut out and painted. The Laurel Fork and Bear Branch tracts will be completed by the first of the year, and the remainder will be done during the winter months.

WESTERN KENTUCKY SUBSTATION.

Pasture Experiments. This experiment, in its fourth pasture year, continues to show a wide difference in the gains of beef cattle in favor of the limestone-superphosphate and rock phosphate treated fields, as compared with the untreated field, tho no additional treatments have been applied since the experiment was begun. The limestone-superphosphate treated field produced 1,435 pounds of beef in 152 days; the rock-phosphate-treated field 1,155 pounds, and the untreated field 515 pounds. Perhaps equally striking evidence of the value of soil treatments for pasture production in western Kentucky is the contrast in

the appearance of the fields. The untreated field produced a thin, short stand of redtop and lespedeza and an abundance of bushes and weeds. Its soil is washing badly in places, even tho the field is terraced. The limestone-superphosphate treated field has an excellent cover of grasses and legumes. Kentucky bluegrass has formed almost a complete sod over much of the field. Practically no bushes or weeds are visible. Nearly all soil washing is prevented by the excellent sod. The rock-phosphate treated field is covered mainly with lespedeza, redtop and certain weeds. Very little soil washing occurs on this field. While these fields were laid out for experimental studies, the visible results are so striking that they have served as a valuable demonstration of the possibilities in pasture production in western Kentucky.

Red Clover. Forty-one Kentucky grown varieties of red clover, all more or less adapted to western Kentucky, yielded from two to three tons of hay from the first cutting. These yields support those of former years in showing that adapted varieties of this crop can be grown with excellent yields on the better soils of western Kentucky.

Legumes in Rotation with Corn and Wheat. In a test of the effect of various legumes as the third crop in rotation with corn and wheat, the check plots are unfertilized and have a mixture of red clover, alsike and lespedeza for the third year crop, which

INCREASE IN CORN AND YIELD OF HAY FOR VARIOUS LEGUMES.

	Yield of Hay, Lbs.	Increase in Corn, Bus.
P* Lespedeza turned under		10.5
P Lespedeza harvested	1940	2.2
LP Lespedeza harvested	3420	16.1
P Cowpeas harvested	3250	—4.9
P Soybeans harvested	2768	—3.2
P Soybeans threshed, straw returned		0.3
LP Sweet clover cut for hay year of seeding; threshed for seed second year, straw returned		17.3
LP Red clover harvested	3264	18.9
LP Red clover turned under		23.0

*P=fertilized with 600 lbs. superphosphate per acre for the rotation.
L=2 tons of limestone applied at the beginning of the experiment.

is harvested. No manure is used in the experiment. The average yield of five crops of hay and four crops of corn following the hay crops (corn a failure in 1930 because of drouth) is given in the table. On the check plots the average yield of corn was 42 bushels and of hay, 1,200 pounds.

Fertilization of Tobacco. The experiment is for the purpose of determining the effect of various fertilizing materials, and their combination, used on tobacco in a six-year rotation consisting two years of tobacco, one year of wheat and three years of hay, including mixed grasses, clover and lespedeza. The complete fertilizer, where used, was approximately a 3-10-10 analysis. Limestone was applied at the rate of 2 tons per acre in 1926. There follows a tabulation of the results of several of the treatments compared with the unfertilized check plots.

	Yield, Lbs.	Increase Lbs.
No treatment	962	
300 lbs. superphosphate	1077	. 115
No treatment	906	
500 lbs. complete fertilizer	1199	293
No treatment	1030	
1000 lbs. complete fertilizer	1415	385
No treatment	934	
Limestone plus 500 lbs. complete fertilizer	1245	311
No treatment	962	
Limestone plus 10 tons manure on each tobacco crop, 300 lbs. superphosphate	1270	308

On limed land, the residue of phosphate and potash used on tobacco increased the yield of wheat about 7 bushels per acre and six cuttings of hay, following the wheat, were increased by an average of approximately 1120 pounds per cutting. The residue of manure and superphosphate used on tobacco on limed land increased the yield of wheat about 16 bushels per acre and the hay about 1650 pounds per cutting.

General Soil Fertility Experiment. This experiment was started in 1929 on abandoned land the soil of which is derived from the Chester sandstone. The rotation is corn, wheat and

mixed grass and legumes. Three corn crops (corn failed in 1930 on account of drouth) three wheat crops and two hay crops (hay failed in 1930) have been harvested. Some of the yields obtained are:

	No Treatment	Limestone Superphosphate
Corn, bus. _____	24.0	43.5
Wheat, bus. _____	2.3	12.3
Hay, lbs. _____	908.	2497.

The tests were run in triplicate each year. One of the three corn crops followed a grass and legume sod, and one crop (the second) followed a crop of cowpeas turned under as a substitute for the regular hay crop in beginning the rotation. One crop followed a very poor sod of the drouth year of 1930.

Orchard Tests. All apple trees made good growth, but the cultivation and cover crop plot has continued to make better growth than the plots in sweet clover and lespedeza, respectively. A few apples were produced, but there was no correlation between production and soil treatment this year.

Strawberry Fertilizer Experiment. The strawberry crop was injured to some extent by spring frosts in 1932, but a moderately good crop was produced. The results continued to show that a foundation treatment of the soil with lime and phosphate and the use of sweet clover as a rotation crop has made a very favorable condition for strawberry production. The addition of fertilizers containing nitrogen, phosphorus or potassium, either separately or in combination, has not increased the yield. The addition of nitrogenous fertilizers sharply reduced the yield in all cases this year. Practically the same results were obtained from nine crops grown on four different series of plots.

FINANCIAL STATEMENT

In Account with the United States Appropriations, 1931-32.

	Hatch Fund	Adams Fund	Purnell Fund
Receipts:			
From the Treasury of the United States, as per appropriations for fiscal year ended June 30, 1932, under acts of Congress approved March 2, 1887 (Hatch Fund), March 16, 1906 (Adams Fund) and February 24, 1925 (Purnell Fund)	\$15,000.00	\$15,000.00	\$60,000.00
Expenditures:			
By personal services	14,692.80	14,921.40	55,588.65
Supplies and materials		53.88	1,100.99
Communication service			120.00
Travel expenses	68.96		2,117.00
Transportation of things			30.35
Publications	238.24		825.26
Heat, light, water and power....		24.72	31.80
Equipment			185.95
Total	\$15,000.00	\$15,000.00	\$60,000.00

We, the undersigned, duly appointed auditors of the expenditures from Federal appropriations reported herein, do hereby certify that we have examined the books and accounts of the Kentucky Agricultural Experiment Station for the fiscal year ended June 30, 1932; that we have found the same well kept and classified as above; and that the balances, receipts and disbursements are as follows:

	Hatch Fund Act of Congress Mar. 2, 1887	Adams Fund Act of Congress Mar. 16, 1906	Purnell Fund Act of Congress Feb. 24, 1925	Totals All Funds
Receipts for the year from the Treasurer of the United States	\$15,000.00	\$15,000.00	\$60,000.00	\$90,000.00
Disbursements for the year	15,000.00	15,000.00	60,000.00	90,000.00
Unexpended balance June 30, 1932	None	None	None	None

Proper vouchers for all of the above disbursements are on file and have been examined by us and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the acts of Congress approved March 2, 1887, March 16, 1906, and February 24, 1925, and in accordance with the terms of said acts, respectively.

Signed :

THOMAS COOPER,
Director of the Experiment Station

D. H. PEAK,
Financial office of the Institution

D. H. PEAK,
Secretary of the Governing Board

Auditors

Attest:

ELOISE CONNER

Custodian of the Seal.

MONTHLY AND ANNUAL MEAN TEMPERATURE

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1872													
1873	29.5	35.4	41.7	52.8	65.5	73.8	75.0	74.1	67.4	53.4	36.8	26.6	
1874	36.0	38.2	43.6	46.3	66.0	77.2	78.0	75.3	70.8	56.6	39.9	39.3	54.0
1875	27.0	29.4	42.4	49.2	63.5	71.9	76.2	71.1	64.0	51.8	45.0	38.4	56.0
1876	41.2	38.6	40.9	52.5	64.8	71.8	77.0				43.2	42.6	52.7
1887											43.8	35.2	
1888	31.2	36.3	41.4	55.6	62.9	72.3	75.8	74.3	62.8	51.0	45.7	36.7	54.0
1889	37.4	31.6	45.8	55.0	62.8	69.2	75.4	72.1	65.4	52.3	43.0	50.2	55.0
1890	44.0	45.1	38.6	55.7	63.3	76.6	75.8	71.3	66.8	56.3	48.6	36.8	56.6
1891	37.1	41.1	40.4	57.3	61.5	75.8	72.8	72.8	71.7	55.4	43.2	42.9	56.0
1892	27.6	41.2	38.8	53.7	62.8	75.8	75.0	74.8	68.4	57.1	41.4	32.9	54.1
1893	23.1	36.5	43.2	56.7	61.2	72.4	78.6	74.0	70.2	57.3	42.8	37.0	54.4
1894	38.0	34.0	49.2	53.9	62.3	74.6	75.6	76.0	71.0	57.6	41.3	37.4	55.9
1895	27.7	23.4	42.7	55.8	62.3	75.4	73.4	75.8	72.8	52.3	45.0	37.4	53.7
1896	34.4	35.2	37.7	61.7	71.0	72.0	75.4	75.2	67.4	54.4	47.6	38.4	55.9
1897	30.0	37.4	47.6	53.3	59.4	72.0	75.7	73.8	72.4	63.9	46.4	36.8	55.7
1898	38.1	36.0	49.0	50.5	65.4	74.4	76.2	75.8	72.0	56.0	43.0	33.2	55.8
1899	33.8	34.4	42.1	55.8	66.7	74.6	77.2	77.0	67.6	60.6	48.2	33.4	55.1
1900	35.9	31.1	39.2	55.0	65.6	72.5	77.0	79.3	73.2	64.9	45.0	37.2	56.3
1901	34.2	29.4	43.8	49.0	62.8	73.9	80.3	74.0	67.0	57.9	40.2	31.2	53.6
1902	32.3	25.0	44.7	52.6	68.2	71.2	76.8	73.8	67.0	59.0	52.6	34.2	54.8
1903	32.1	35.6	50.4	53.4	67.7	67.7	76.6	74.4	69.8	56.9	40.0	28.5	54.4
1904	29.6	31.2	45.6	47.8	63.8	71.8	73.9	74.2	69.4	57.0	44.2	34.0	53.5
1905	24.4	24.9	49.2	53.8	65.8	72.3	74.6	73.6	68.4	55.4	43.7	35.3	53.5
1906	37.4	31.9	35.8	56.6	64.2	71.8	73.6	75.8	70.6	54.7	45.2	36.4	54.5
1907	40.4	32.4	51.5	45.3	59.1	68.6	75.5	72.8	68.0	53.4	42.2	36.7	53.8
1908	33.0	33.2	49.6	54.7	64.8	71.8	76.0	74.6	71.8	57.6	47.8	37.8	56.1
1909	37.2	41.0	42.6	53.9	61.8	72.8	72.7	74.5	65.6	52.8	53.0	27.8	54.6
1910	32.0	31.4	54.4	54.1	59.1	68.8	74.8	72.6	69.6	59.6	39.6	28.6	53.7
1911	38.3	40.4	42.9	51.6	69.5	73.8	75.6	75.8	72.5	58.2	39.8	40.8	56.6
1912	23.2	27.6	39.3	56.6	64.8	69.2	75.3	72.2	69.6	59.0	44.5	35.8	53.1
1913	41.6	32.8	44.4	53.2	64.9	73.4	78.2	76.7	68.9	56.5	49.4	38.0	56.5
1914	37.2	29.3	39.6	53.7	65.8	75.8	77.6	74.8	66.8	58.9	45.7	30.4	54.6
1915	32.0	39.8	35.8	59.2	62.4	70.2	74.5	69.5	69.5	59.8	48.8	35.9	54.8
1916	39.7	32.8	41.2	52.4	67.0	69.0	78.0	76.0	66.7	57.6	47.4	34.0	55.2
1917	35.2	31.8	44.2	53.8	56.9	70.0	74.5	74.4	67.2	50.0	44.0	25.3	52.3
1918	19.8	37.9	49.2	51.8	69.4	72.2	72.6	79.4	62.4	61.1	44.2	42.8	55.2
1919	36.9	36.0	45.6	54.3	62.2	76.4	78.8	73.5	71.5	64.0	44.9	31.2	56.3
1920	30.1	32.6	44.9	49.7	62.4	71.3	74.4	72.2	69.9	62.1	43.3	36.2	54.1
1921	37.4	38.2	54.6	57.5	64.9	76.2	80.2	74.6	73.2	56.8	48.0	38.9	58.4
1922	32.6	38.2	46.8	57.0	68.4	74.6	75.8	74.7	72.6	61.0	47.2	39.1	57.3
1923	39.1	31.6	42.6	53.3	63.0	74.0	76.6	74.4	69.0	56.2	44.8	45.2	55.8
1924	29.5	33.4	39.1	54.9	58.2	73.0	73.2	75.1	63.7	62.4	45.0	34.0	53.5
1925	32.8	43.0	46.6	59.2	59.8	75.8	75.0	76.2	76.2	50.2	43.2	31.8	55.8
1926	32.0	37.3	36.7	48.8	64.6	69.4	76.8	76.0	71.6	57.2	40.8	35.0	53.8
1927	33.4	43.4	47.7	55.4	63.4	68.8	75.3	69.5	72.2	61.1	49.6	35.0	56.2
1928	32.6	35.5	42.1	50.6	62.2	67.2	75.8	75.2	64.2	61.0	44.9	39.4	54.2
1929	31.9	29.2	49.4	57.8	62.2	70.6	75.0	72.4	68.2	55.1	41.8	36.3	54.2
1930	32.6	43.8	40.8	57.6	65.4	72.8	79.6	76.2	71.2	54.7	45.6	33.2	56.0
1931	35.6	38.2	37.8	54.0	61.2	74.8	79.4	74.2	73.4	60.8	54.8	44.4	57.5
1932	42.8	44.6	37.0	53.9	64.0	73.8	77.0	75.6	69.0	56.2	42.6	36.6	56.1
Ave.	33.7	34.9	43.7	53.8	63.8	72.6	76.0	74.4	69.2	57.2	44.8	36.0	55.0

MONTHLY AND ANNUAL PRECIPITATION

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
1872											1.21	3.30	
1873	2.53	4.05	3.73	2.89	6.05	4.49	3.37	2.94	1.60	5.47	1.92	4.48	43.52
1874	5.41	4.89	5.90	6.81	0.79	3.56	6.26	1.57	2.89	0.92	4.27	3.83	47.09
1875	2.61	3.12	6.18	2.06	2.43	4.16	11.24	0.62	1.72	2.37	5.87	3.68	46.06
1876	6.06	1.66	3.63	4.20	2.16	4.13	3.84						
1887											3.02	2.71	
1888	4.39	2.93	5.82	3.17	3.29	2.97	4.21	8.76	1.22	3.02	5.15	1.88	46.81
1889	5.66	1.78	1.63	1.52	3.53	3.49	5.82	1.15	6.79	3.06	5.34	1.73	41.50
1890	5.34	8.13	9.91	3.59	4.71	7.43	3.14	7.32	1.82	2.38	3.54	4.05	61.36
1891	4.70	4.86	7.63	1.85	1.17	5.33	3.23	6.48	1.26	1.33	5.35	2.82	45.51
1892	2.35	3.10	4.01	6.57	5.32	3.81	6.22	3.28	4.10	0.45	3.72	3.03	45.96
1893	2.10	4.44	3.30	5.81	3.88	4.24	3.11	1.86	2.25	5.59	3.36	2.61	42.55
1894	3.58	3.35	2.13	4.19	3.81	4.44	0.87	3.67	4.05	1.40	1.38	3.45	36.32
1895	5.60	0.52	2.79	3.17	4.05	2.93	5.07	1.56	0.33	1.28	2.52	5.50	35.32
1896	1.25	3.15	5.41	0.40	3.20	3.74	10.39	3.37	4.25	1.27	4.30	2.66	43.29
1897	2.59	6.33	6.55	5.80	4.48	4.77	4.34	3.21	0.80	0.38	4.83	5.11	49.19
1898	9.56	2.20	8.18	3.29	6.13	7.94	5.72	2.99	3.55	5.27	2.89	2.80	60.52
1899	6.69	2.84	8.61	2.16	3.63	2.55	0.97	4.18	1.90	2.09	1.70	2.92	40.24
1900	2.13	3.17	1.98	1.23	3.54	2.19	2.80	5.75	1.85	0.79	6.38	1.86	33.67
1901	1.49	0.62	2.23	4.52	2.67	3.70	2.61	3.74	2.18	1.33	1.73	3.50	30.32
1902	4.77	0.90	2.92	1.27	2.43	5.19	2.33	1.89	2.60	2.11	3.09	6.60	36.10
1903	1.68	6.16	2.24	3.29	1.75	2.71	2.62	1.49	0.81	2.12	2.84	1.99	30.70
1904	1.92	2.38	4.75	3.08	2.60	2.51	3.13	2.44	1.71	0.57	0.53	1.00	28.72
1905	2.04	2.13	5.87	2.87	5.54	3.31	4.94	4.11	3.20	3.45	3.58	4.13	45.17
1906	2.29	1.84	6.45	1.11	3.15	4.68	3.89	4.92	5.03	0.74	3.95	4.54	42.59
1907	9.06	1.89	4.13	1.83	3.89	3.65	4.42	2.07	2.72	2.76	2.67	2.28	41.37
1908	1.85	4.81	8.17	4.99	4.20	2.12	3.60	2.98	0.38	0.72	1.65	2.13	37.60
1909	3.35	6.86	3.97	6.72	4.15	5.41	5.98	1.26	4.88	2.05	1.96	2.77	49.36
1910	4.46	4.11	0.46	4.22	6.24	5.92	7.66	4.15	7.92	1.67	1.72	2.31	51.34
1911	2.44	2.21	2.31	4.46	1.07	3.01	0.92	2.84	4.37	3.67	3.84	6.20	37.34
1912	1.78	2.50	4.36	6.89	5.11	2.15	4.70	3.23	2.09	0.51	1.02	3.66	38.00
1913	10.35	2.61	6.04	2.41	4.32	3.29	2.43	1.00	1.76	3.40	4.00	2.74	44.35
1914	2.50	3.87	2.24	2.23	1.65	4.77	2.63	4.69	1.82	5.32	1.62	4.40	37.74
1915	4.38	1.12	1.49	0.65	7.23	3.20	5.72	6.03	3.74	0.81	3.90	6.67	44.94
1916	5.65	3.40	3.30	1.01	2.92	5.33	1.72	2.34	2.75	2.04	1.25	3.63	35.34
1917	5.67	2.12	5.48	3.97	3.51	3.54	2.80	1.94	2.46	2.36	1.03	1.97	36.85
1918	4.46	1.92	1.55	2.09	4.13	3.61	2.01	2.68	1.41	4.57	2.24	4.83	35.50
1919	2.48	1.61	3.71	3.51	6.38	4.49	2.28	2.39	1.12	7.95	8.50	6.70	51.12
1920	3.26	2.11	4.62	6.42	2.51	2.39	1.73	6.71	4.88	2.75	2.22	1.40	43.00
1921	3.24	2.62	5.06	3.28	1.60	2.16	1.04	3.88	5.10	2.46	6.89	5.74	43.07
1922	1.87	3.12	7.75	4.46	3.10	2.44	2.13	2.20	5.99	1.25	0.88	5.67	40.86
1923	6.63	4.40	4.65	5.43	1.66	3.55	5.01	4.02	1.51	0.56	2.71	6.50	46.63
1924	5.00	2.60	2.42	3.75	3.04	4.04	2.77	2.28	3.89	0.11	1.32	5.59	36.81
1925	3.41	3.02	3.45	2.49	3.56	3.96	3.63	1.15	1.70	5.83	4.52	0.80	37.52
1926	4.43	2.27	2.52	1.54	2.06	2.78	5.95	7.03	4.04	7.46	3.21	4.32	47.61
1927	6.53	1.87	5.17	3.89	5.76	2.14	2.95	2.09	2.29	1.65	4.88	3.64	42.86
1928	2.68	2.30	2.67	2.79	2.12	10.62	5.16	4.30	0.71	2.69	3.79	1.92	41.75
1929	2.83	3.37	3.67	2.99	5.59	4.25	4.12	1.49	4.35	2.99	3.92	1.88	41.45
1930	4.44	2.91	2.54	0.81	3.35	1.89	0.45	1.69	2.80	0.63	1.59	1.79	24.89
1931	0.77	3.40	3.19	4.36	1.13	1.83	8.50	2.40	2.15	4.44	2.50	5.84	40.51
1932	8.46	3.01	4.95	3.32	0.60	6.80	2.58	8.96	2.76	2.28	2.09	2.33	48.14
Ave.	4.10	3.06	4.34	3.37	3.49	3.95	3.94	3.40	2.82	2.51	3.17	3.61	41.84

EXTREMES OF PRECIPITATION AND WIND

Month	PRECIPITATION			WIND			
	Greatest in 24 Hours	Year	Day	Max. Vel. †	Dir.	Year	Day
January	3.50	1913	11	49	w	1928	24
February	3.04	1909	23-24	46	sw	1890*	25
March	3.61	1913	25-26	51	sw	1919	17
April	3.24	1909	29-30	49	sw	1909*	29
May	2.61	1898	6-7	49	sw	1924	24
June	5.50	1928	28-29	46	n	1890*	29
July	4.02	1875	11-12	49	nw	1929	1
August	3.06	1932	1-2	54	s	1918	6
September	5.45	1922	3	51	w	1899	14
October	2.34	1931	13-14	39	nw	1904*	21
November	3.95	1919	25-26	52	nw	1929	27
December	3.63	1919	6	46	sw	1895*	26

*Also in subsequent years.

†Corrected velocity.

TEMPERATURE EXTREMES

Month	Highest	Year	Day	Lowest	Year	Day
January	72	1929	18	-14	1918	12
February	75	1932	10	-20	1899	13
March	86	1929	25	-1	1873	4
April	90	1925	24	15	1875	18
May	93	1911	28	30	1876	1
June	99	1914	27	40	1910	3
July	104	1930	28	51	1891	9
August	100	1918	6	46	1915	31
September	99	1932	1	32	1899	30
October	89	1919	2	21	1925	29
November	78	1895	7	-3	1929	30
December	71	1875	31	-9	1917	10

